THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. I.—*Contributions to Meteorology;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Twentieth paper. With Plates I and II.

[Read before the National Academy of Sciences, Nov. 13, 1883, and April 15, 1884.]

Reduction of Barometric observations to sea-level.

IN my fifteenth paper of contributions to Meteorology, I endeavored to determine the proper reduction to sea-level of barometric observations made at elevated stations. For this purpose I made an extensive comparison of observations at five mountain stations; three in the United States and two in Europe. The reductions deduced from these observations were compared with the reductions computed from the theories of Laplace and Plantamour and exhibited very great discrepancies. For each of the stations the discrepancies appear at the lowest pressures, and also at the highest pressures, while for a medium pressure the observed reductions agree with the computed reductions. In order to discover if possible the cause of these discrepancies I selected for examination all the cases in which during a period of three years there was a decided area of high or low pressure near either of these five stations. Table I shows the most remarkable cases of barometric minima on Mt. Washington during a period of three years. Column first gives the number of reference; column second the date of the barometric minimum; and column third gives the height of the barometer at sea-level deduced from the observations at Burlington, Vt. and Portland, Me. The distance of Mt. Washing-

ton from Portland is almost exactly two-thirds of its distance from Burlington, and I have assumed that the pressure at sea-level under Mt. Washington is given by the formula $\frac{1}{5}(2B+3P)$. The temperature at sea-level given in column fourth is deduced from the observations at Burlington and Portland by the same formula. Column fifth shows the pressure observed on Mt. Washington, column sixth the temperature on Mt. Washington and column seventh gives the half sum of the temperatures in columns four and six.

The numbers in this table were arranged in the order of the mean temperatures given in column seventh, and were divided into four equal groups and the average of the numbers in the several columns for each group was computed. The results are given in the first five lines of table III, under the heading barometric minima; and these results may be regarded as normal values deduced from the barometric minima of three years.

I next proceeded to compare these results with theory. Column sixth of table III shows the Mt. Washington observations reduced to sea-level by the use of Guyot's tables as contained in his collection of tables, series D, page 33, employing the mean temperatures given in column fifth. Column seventh shows the difference between the numbers in columns one and six.

It has been a common opinion among meteorologists that anomalies like those shown in column seven result from the erroneous assumption that the mean temperature of the air column between the upper and lower stations is equal to the half sum of the temperatures observed at the two stations. In order to test this explanation I computed what must be assumed as the true temperature of the air column in order that the Mt. Washington observations, reduced to sea-level by the Laplace formula, might agree with the barometric heights observed at sea-level, and the results are shown in column eighth. It will be seen that the differences between the numbers in columns five and eight range from 5° to 10°.

I next computed the reduction of the Mt. Washington observations to sea-level by Ferrel's tables, published in his Meteorological Researches, Part III, pages 40–41, and the results are shown in column ninth. Column tenth shows the difference between the numbers in columns one and nine; column eleventh shows what must be assumed as the true temperature of the air-column in order that the Mt. Washington observations reduced to sea-level by Ferrel's tables may agree with the barometric heights observed at sea-level. It will be seen that the differences between the numbers in columns five and eleven range from 8° to 15°. Some remarks upon these results will be found on a subsequent page.

TABLE I.—*Barometric minima on Mt. Washington.*

No.	Date.	Sea level. Bar.	Sea level. Therm.	Mt. Wash'n. Bar.	Mt. Wash'n. Ther.	Mean temp.	No.	Date.	Sea level. Bar.	Sea level. Therm.	Mt. Wash'n. Bar.	Mt. Wash'n. Ther.	Mean temp.
	1872.							1874.					
1	Sep. 20.1	29·69	55°·2	23·45	39	47°·1	55	Jan 16.1	29·67	9°·8	22·72	−25	−7°·6
2	Oct. 2.2	·74	53·8	·32	24	38·9	56	26.1	30·53	− 9·8	23·10	−39	−24·4
3	14.1	·45	41·6	·23	27	34·3	57	28.3	29·80	20·2	·11	4	12·1
4	20.1	·97	37·0	·43	17	27·0	58	30.1	30·32	0·0	·20	−30	−15·0
5	Nov. 7.3	·26	40·4	22·78	20	30·2	59	Feb 11.1	29·65	16·0	22·97	−15	0·5
6	8.1	·33	41·6	·80	21	31·3	60	16.2	·45	34·4	23·03	13	23·7
7	15.1	·58	36·6	23·15	22	29·3	61	17.1	·65	23·2	·02	− 5	9·1
8	29.2	·72	32·6	22·89	13	22·8	62	27.2	·92	26·6	·14	− 4	11·3
9	30.1	·45	15·8	·63	5	10·4	63	Mar 10.1	·32	20·2	22·82	11	15·6
10	30.3	·63	16·2	·73	3	9·6	64	12.3	·41	12·2	·77	− 9	1·6
11	Dec. 1.1	·84	20·6	·85	4	12·3	65	23.1	·57	24·0	·92	− 5	9·5
12	3.1	·56	36·2	23·02	17	26·6	66	23.3	30·05	12·4	23·00	−18	− 2·8
13	10.1	·61	11·8	22·78	3	7·4	67	Apr. 3.2	29·63	40·6	·11	4	22·3
14	22.2	30·17	6·6	23·05	− 9	− 1·2	68	4.2	·90	22·6	·07	−13	4·8
15	24.3	·48	−8·8	·05	−16	−12·4	69	26.1	·38	32·6	22·95	11	21·8
16	28.1	29·95	−1·8	22·75	−20	−10·9	70	30.2	·38	38·2	·67	8	23·1
	1873.						71	May 1.1	·35	39·6	·82	10	24·8
17	Jan. 6.1	·62	32·8	·98	13	22·9	72	6.1	·73	45·0	23·38	18	31·5
18	9.2	·79	26·2	23·07	12	19·1	73	22.1	·70	47·0	·37	24	35·5
19	11.3	30·15	8 2	·06	−11	− 1·4	74	June 1.1	·57	56·8	·38	34	45·4
20	25.1	29·73	13·4	22·98	1	7·2	75	13.1	·81	57·4	·48	29	43·2
21	28.3	·86	14·8	23·00	− 1	6·9	76	Sep. 30.2	·39	55·6	·06	27	41·3
22	Feb. 8.2	·46	40·4	·01	16	28·2	77	Oct. 1.1	·65	48·2	·28	20	34·1
23	10.1	30·10	0·0	22·96	− 4	− 2·0	78	11.1	·63	54·6	·37	28	41·3
24	22.2	29·36	19·8	·66	2	10·9	79	19.1	·70	40·8	·25	14	27·4
25	24.1	·47	−1·2	·51	−14	− 7·6	80	30.1	·72	53·8	·38	27	40·4
26	Mar. 3.3	·53	16·2	·92	4	10·1	81	Nov 11.3	·86	34·4	·23	9	21·7
27	9.1	·53	31·4	·94	14	22·7	82	21.1	·45	33·2	·02	9	21·1
28	16.3	·60	27·6	·74	7	17·3	83	24.1	·09	37·6	22·62	15	26·3
29	24.1	·96	14·6	·92	3	8·8	84	29.2	·62	34·2	23·05	4	19·1
30	27.1	·57	19·2	·78	8	13·6	85	Dec 18.1	·73	14·8	22·75	−19	− 2·1
31	30.1	28·91	35·4	·72	23	29·2	86	24.2	·59	35·8	23·04	9	22·4
32	Apr 14.1	29·61	36·6	23·10	20	28·3	87	29.2	·88	26·6	·02	− 3	11·8
33	26.1	·47	43·0	·15	20	31·5	88	30.2	30·21	10·8	·01	−20	− 4·6
34	M'y 13.2	·45	54·8	·18	31	42·9		1877.					
35	15.1	·64	41·2	·14	19	30·1	89	Jan. 3.1	29·80	7·4	22·78	−22	− 7·3
36	June 5.1	·56	54·4	·46	40	47·2	90	4.1	·81	2·4	·76	−25	−11·3
37	20.2	·54	79·8	·47	49	64·4	91	7.2	·18	33·6	·64	11	22·3
38	July 6.1	·80	69·4	·68	44	56·7	92	14.1	·66	16·4	·83	− 8	4·2
39	Au. 24.1	30·01	54 0	·62	27	40·5	93	24.3	·89	6·8	·77	−25	− 9·1
40	Sep. 2.1	29·73	62·8	·51	36	49·4	94	Feb 13.1	30·11	13·6	23·04	−15	− 0·7
41	20.2	·84	54·8	·40	24	39·4	95	18.1	29·62	18·0	22·83	−11	3·5
42	Oct. 7.1	·56	43·8	·44	34	38·9	96	19.1	·61	14·8	·83	−11	1·9
43	12.3	·72	48·0	·51	31	39·5	97	24.3	·64	33·4	23·24	16	24·7
44	27.2	·30	56·0	·21	34	45·0	98	Mar. 9.2	·13	42·2	22·86	28	35·1
45	Nov. 8.3	·44	44·2	·11	21	32·6	99	15.3	·72	23·4	·92	− 8	7·7
46	13.2	·58	29·0	·03	9	19·0	100	19.1	·99	14·2	·98	−20	− 2·9
47	18.2	28·88	31·2	22·56	30	30·6	101	29.1	·37	34·4	23·06	27	30·7
48	25.2	29·26	25·4	·84	8	16·7	102	Apr. 6.1	·44	37·6	·05	14	25·8
49	26.2	·80	14·4	·91	−17	− 1·3	103	20.3	·51	43·2	·26	25	34·1
50	Dec. 4.3	·82	43·2	23·31	15	29·1	104	May 3.3	·60	45·4	·10	16	30·7
51	13.3	·39	18·6	·07	22	20·3	105	June 4.1	·71	70·6	·52	39	54·8
52	14.2	·79	24·5	·09	− 1	11·7	106	22.1	·61	62·0	·39	34	48·0
53	28.2	·42	26·0	22·76	− 5	10·5	107	July 2.1	·64	68·2	·54	43	55·6
54	29.3	·57	25·4	·90	7	16·2							

I next selected for examination all the cases in which, during a period of three years there was a decided area of high pressure over Mt. Washington. The results are shown in table II, which is constructed upon the same principles as table I. These numbers were then arranged in the order of the mean temperatures given in column seventh and were divided into four equal groups, and the average of the numbers in the several columns for each group was computed. The results are given in the first five lines of table III under the heading barometric maxima.

I then proceeded to compute the remaining columns of the table in the same manner as has been explained for barometric minima.

We see from table III that if we undertake to explain the differences between the pressures observed at sea-level and the Mt. Washington observations when reduced to sea-level in accordance with theory, we must admit errors of ten degrees in the assumed temperature of the air-column when the computations are made by Guyot's tables, and errors of fifteen degrees when the computations are made by Ferrel's tables; and this is true not simply for exceptional cases but for the average of all the barometric minima during a period of three years. The question to be decided is, can errors of such magnitude be admitted? In order to decide this question, I have consulted all the available observations of the thermometer made in the neighborhood of Mt. Washington. In the Annual Report of the Chief Signal Officer for 1873 is given a series of hourly observations for May 1873 on the summit of Mt. Washington and also at a station situated on the side of the mountain 3387 feet below the summit; and for the month of June 1873 is given a series of hourly observations on the summit of Mt. Washington and at three stations on the side of the mountain, one situated 732 feet below the summit, a second 2227 feet below the summit, and a third 3387 feet below the summit. These observations can be compared with the tri-daily observations made at Burlington and Portland, and thus for the month of May we have the temperature given at one station intermediate between sea-level and the summit of Mt. Washington, and for the month of June we have the temperature at three intermediate stations. As the evidence for the month of June is much fuller than for the month of May, I have selected this month for a careful comparison and the details are given in table IV, where column first shows the day of the month and the four following columns show the temperatures observed at 7.35 A. M. at the elevations indicated at the top of the columns. The sixth column shows the temperature deduced from the observations at Burlington and Portland by the formula $\frac{1}{5}(2B+3P)$.

TABLE II.—*Barometric maxima on Mt. Washington.*

No.	Date.	Sea level. Bar.	Sea level. Therm.	Mt. Wash'n. Bar.	Mt. Wash'n. Ther.	Mean temp.	No.	Date.	Sea level. Bar.	Sea level. Therm.	Mt. Wash'n. Bar.	Mt. Wash'n. Ther.	Mean temp.
	1872.							1874.					
1	Sep. 11.1	30·33	57°·0	24·15	48	52°·5	54	Jan. 3.1	30.28	34°·6	23·93	33	33°·8
2	24.2	·32	67·2	·20	40	53·6	55	6.1	·63	20·8	24·00	27	23·9
3	Oct. 6.1	·15	58·8	·01	44	51·4	56	18.2	·37	30·8	23·97	29	29·9
4	22.1	·19	47·6	·06	40	43·8	57	20.3	·61	13·2	·95	14	13·6
5	24.3	·51	38·6	·18	33	35·8	58	Feb. 2.1	·81	−10·8	·89	0	− 5·4
6	29.3	·62	34·2	·16	26	30·1	59	15.1	·28	26·0	·80	16	21·0
7	Nov. 5.3	·30	38·2	23·95	24	31·1	60	18.3	·39	18·0	·90	20	19·0
8	11.1	·26	34·2	·89	24	29·1	61	22.2	·28	31·6	·84	29	30·3
9	17.3	·48	28·0	·84	12	20·0	62	Mar. 6.1	·48	17·2	·79	6	11·6
10	Dec 12.1	·38	6·4	·61	3	4·7	63	16.1	·43	28·6	24·00	37	32·8
11	18 1	·32	15·2	·69	7	11·1	64	17.1	·34	38·4	23·95	31	34·7
12	19.3	·45	22·4	·75	7	14·7	65	Apr 13.3	·25	34·2	·83	25	29·6
13	30.3	·45	1·6	·68	− 2	− 0·2	66	17.1	·29	33·4	·80	19	26·2
	1873.						67	18.2	·35	43·6	·92	19	31·3
14	Jan. 2.1	·49	6·0	·82	5	5·5	68	M'y 12.1	·39	51·2	24·09	37	44·1
15	5.1	·31	21·2	·79	17	19·1	69	29.2	·13	64·8	·07	52	58·4
16	7.3	·33	18·2	·76	11	14·6	70	Jun 16.1	·11	67·6	·08	45	56·3
17	13.1	·43	8·8	·74	5	6·9	71	Jul. 19.1	·18	71·0	·15	51	61·0
18	15.1	·77	0·5	24·03	9	4·7	72	Au. 17.1	·20	66·2	·13	45	55·6
19	Feb. 5.3	·13	14·0	23·52	9	11·5	73	26.1	·29	57·6	·09	37	47·3
20	15.3	·40	18·0	·83	10	14·0	74	Sep. 14.1	·26	60·8	·20	55	57·9
21	18.1	·35	20·2	·81	13	16·6	75	17.1	·29	57·2	·16	49	53·1
22	Mar. 6.1	·57	12·8	·90	10	11·4	76	19.1	·32	56·0	·15	45	50·5
23	7.1	·37	25·0	·84	16	20·5	77	Oct. 7.3	·33	53·6	·09	35	44·3
24	15.1	·24	32·2	·76	13	22·6	78	24.1	·48	46·8	·21	36	41·4
25	28.2	·10	36·6	·70	16	26·3	79	25.1	·41	45·2	·19	40	42·6
26	Apr. 5.2	·16	38·6	·82	24	31·3	80	Nov. 4.2	·25	49·0	·00	35	42·0
27	16.3	·15	36·8	·89	23	29·9	81	7.3	·38	41·8	·05	34	37·9
28	May 8.1	·43	51·6	24·11	30	40·8	82	16.3	·52	32·8	·04	22	27·4
29	21.1	·31	55·2	·04	30	42·6	83	Dec. 1.1	·61	12·2	23·78	− 3	4·6
30	26.1	·06	66·4	·02	43	54·7	84	4.3	·52	20·4	·90	18	19·2
31	31.3	·24	48·4	·01	31	39·7	85	16.2	·29	22·4	·70	19	20·7
32	June 8.2	·16	66·6	·01	40	53·3		1877.					
33	25.2	·29	77·6	·25	55	66 3	86	Jan. 6.2	·18	26·6	·64	17	21·8
34	Jul 13.2	·09	75·2	·11	52	63·6	87	17.3	·54	15·4	·81	7	11·2
35	28.1	·15	70·6	·12	48	59·3	88	22.1	·31	21·2	·66	5	13·1
36	31.2	·06	75·0	·11	53	64·0	89	30.3	·46	30·2	·96	23	26·6
37	Au. 18.1	·24	63·2	·13	41	52·1	90	Feb. 3.1	·11	34·4	·74	22	28·2
38	21.1	·22	64·2	·17	51	57·6	91	4.2	·28	39·4	·82	22	30·7
39	29.1	·29	66·2	·18	47	56·6	92	11.2	·23	41·0	·77	23	32·0
40	Sep. 9.3	·36	53·8	·14	35	44·4	93	Mar. 1.3	·17	32·8	·70	19	25·9
41	17.3	·21	51·4	·07	31	41·2	94	13.3	·23	26·2	·71	16	21·1
42	22.1	·43	51·0	·07	30	40·5	95	25.3	·35	37·6	·94	30	33·8
43	27.1	·23	60·6	·07	50	55·3	96	Apr. 1.1	·39	42·2	·93	18	30·1
44	Oct. 10.2	·14	58·2	·06	50	54·1	97	13.2	·15	52·8	·80	20	36·4
45	15.3	·43	47·0	·13	32	39·5	98	23.1	·26	51·4	24·02	33	42·2
46	17.3	·32	41·8	·02	29	35·4	99	M'y 13.1	·27	56·2	·03	33	44·6
47	Nov. 2.1	·28	36·0	23·79	18	27·0	100	29.1	·20	66·6	·08	45	55·8
48	7.1	·42	27·4	·85	11	19·2	101	Jun 12.2	·18	70·6	·08	54	62·3
49	23.1	·33	26·2	·74	15	20·6	102	15.1	·15	69·4	·06	45	57·2
50	Dec. 2.2	·52	14·4	·94	8	11·2	103	Jul. 23.1	·20	70·0	·14	47	58·5
51	8.1	·64	18·6	24·05	15	16·8	104	27.2	·08	71·0	·05	61	66·0
52	16.3	·19	26·8	23·81	27	26·9	105	Aug. 1.1	·26	67·6	·19	52	59·8
53	22.3	·45	20·8	·83	10	15·4	106	24·1	·06	71·8	·09	56	63·9

TABLE III.—*Mean Results: Barometric Minima.*

Mount Washington, 6,285 feet above sea-level.

Low'r station. Barom.	Ther.	Upper station. Barom.	Therm.	mean temp.	Redu'd Lapl ce	O−C	t'	Red'ed. Ferrel.	O−C	t''	Red'ed. Loomis	O−C
				°			°			°		
29·910	8°·77	22·911	−16°00	− 3°62	29·728	+·182	−13°00	29·644	+·266	−18°68	29·635	+·275
·612	23·54	·925	+ 4·22	+13·88	·435	·177	+ 3·72	·376	·236	− 0·72	·377	+·235
·473	37·44	·985	+16·18	26·81	·299	·174	+16·68	·256	·217	+12·62	·264	+·209
·616	54·71	23·365	+31·00	42·86	·532	·084	+37·41	·498	·118	+35·00	·523	+·093
				Pike's Peak, 8,794 feet above Denver.								
24·648	10·71	17·197	−10·12	+ 0 29	24·667	−·019	+ 1·19	24·585	+·063	− 3·02	24·567	+·081
·507	28·68	·290	− 0·08	14·30	·512	−·005	14·55	·453	+·054	+11·33	·445	+·062
·505	37·75	·381	+ 6·00	21·87	·492	+·013	21·19	·446	+·059	+18·52	·442	+·063
·574	52·63	·557	+18·17	35·40	·489	+·085	30·72	·456	+·118	+28·61	·465	+·109
				Summit, 6,986 feet above Sacramento.								
29·849	42·21	22·893	21·87	32·04	29·883	−·034	33·97	29·844	+·005	31·76	29·818	+·031
·881	49·60	·921	28·79	39·19	·795	+·086	34·19	·761	+·120	32·03	·743	+·138
·909	55·55	23·003	30·78	43·16	·834	+·075	38·75	·801	+·108	36·72	·787	+·122
·891	62·84	·081	42·52	52·68	·778	+·113	45·81	·745	+·146	43·80	·744	+·147
				Grand St. Bernard, 6,742 feet above Geneva.								
28·305	29·17	21·666	2·79	15·98	28·292	+·013	15·26	28·234	+·071	11·62	28·236	+·069
·371	36·99	·833	12·87	24·93	·357	·014	24·10	·310	·061	21·06	·317	+·054
·172	43·54	·752	22·89	33·22	·115	·057	29·71	·078	·094	27·08	·091	+·081
·276	55·36	·968	31·21	43·29	·237	·039	40·77	·202	·074	38·46	·227	+·049
				Colle di Valdobbia, 7,831 feet above Alessandria.								
29·300	29·44	21·619	12·51	20·97	29·369	−·069	24·39	29·309	−·009	21·46	29·313	−·013
·340	43·18	·757	20·91	32·04	·339	+·001	31·95	·288	+·052	29·21	·302	+·038
·220	50·34	·756	27·39	38·87	·203	+·017	37·99	·161	+·059	35·66	·184	+·036
·297	62·80	·913	35·89	49·34	·223	+·074	45·18	·180	+·117	42·92	·220	+·077

Barometric Maxima.

Mount Washington and sea-level.

30·468	14·66	23·812	8·73	11·70	30·614	−·146	19·99	30·549	−·081	16·64	30·548	−·080
·296	32·30	·842	21·03	26·67	·392	·096	32·57	·348	·052	30·05	·357	−·061
·324	17·67	24·042	33·48	40·57	·423	·099	47·07	·388	·064	44·77	·410	−·086
·188	67·00	·118	49·04	58·03	·257	·069	62·89	·223	·035	60·45	·269	−·081
				Pike's Peak and Denver.								
24·922	23·80	17·774	6·44	15·12	25·181	−·259	28·40	25·122	−·200	26·14	25·114	−·192
·886	40·27	·836	15·19	27·73	·019	·133	34·95	24·980	−·094	33·02	24·981	−·095
·894	54·50	·929	23·42	38·96	24·943	·049	41·74	·911	−·017	40·00	·925	−·031
·905	69·32	18·097	37·44	53·38	·922	·017	54·59	·893	+·012	52·69	·930	−·025
				Summit and Sacramento.								
30·305	39·32	23·486	23·57	31·44	30·668	−·363	52·50	30·628	−·323	50·38	30·600	−·295
·244	48 89	·472	30·74	39 81	·500	·256	55·05	·466	·222	53·02	·447	−·203
·123	62·07	·482	43·82	52·94	·292	·169	63·50	·258	·155	61·32	·256	−·133
29·973	76·14	·480	58·86	67·50	·059	·086	73·20	·024	·051	70·88	·018	−·045
				Grand St. Bernard and Geneva.								
28·958	28·26	22·347	16·11	22·19	29·074	−·116	28·80	29·020	−·062	26·10	29·026	−·068
·801	44·17	·362	27·28	35·73	28·865	−·064	39·60	28·826	−·025	37·31	28·842	−·041
·774	57·74	·471	39·16	48·45	·803	−·029	50·32	·768	+·006	48·07	·801	−·027
·730	72·86	·534	49·84	61·35	·691	+·039	58·71	·656	+·074	56·34	·708	+·022
				Colle di Valdobbia and Alessandria.								
30·046	31·64	22·351	22·69	27·16	30·237	−·191	36·68	30·182	−·136	34·23	30·191	−·145
29·958	47·93	·376	29·12	38·53	30·043	−·085	42·91	29·998	−·040	40·67	·021	−·063
·822	62·53	·406	39·97	51·25	29·845	−·023	52·50	·801	+·021	50·06	29·846	−·024
·759	78·58	·507	52·16	65·37	·725	+·034	63·34	·685	+·074	61·16	·754	+·005

In order to deduce from these observations the most probable value of the mean temperature of the air column I proceeded as follows:

I multiplied the half sum of the temperatures observed at the first and second stations by the difference of elevation between the two stations; I multiplied the half sum of the temperatures observed at the second and third stations by their difference of elevation. I proceeded in like manner with the third and fourth stations, and also with the fourth and fifth. I then divided the sum of these four products by the difference of level between the first and fifth stations and regarded the quotient as representing the mean temperature of the air column. The difference between this result and the half sum of the temperatures at the first and fifth stations is given in column seventh, where the + sign indicates that the mean temperature of the air column is greater than the half sum of the temperatures at the upper and lower stations. I proceeded in the same manner with the observations at 4.35 P. M. and 11 P. M.

TABLE IV.—*Change of temperature with elevation.*

1873	7·35 A. M.						4·35 P. M.						11 P. M.					
June	6285	5553	4058	2898	134	Diff.	6285	5553	4058	2898	134	Diff.	6285	5553	4058	2898	134	Diff.
1	34	38·5	45	51	61·6	+1°·0	42	48·5	55·5	63·5	74·0	+2°·1	37	41·5	48	55	64·2	+1·4
2	30	32	35·5	43·5	56·0	−1·5	35	42·5	47	56	60·4	+3·6	29	32·5	39	39·5	54·2	−0·8
3	32	34·5	40	46	50·6	+1·5	38	46	53	57	57·2	+5·5	37	41·5	43·5	44	51·8	+0·4
4	38	40	45·5	47·5	48 8	+2·0	47	50	57	61	55 4	+4·9	47	49	53	57	56·6	+2·2
5	40	42	46	53	54·4	+1·8	42	44·5	49	58	57·2	+2·9	37	40·5	45	47	52·6	+1·2
6	41	45	49·5	54·5	55·6	+2·8	43	50	55	61	59·6	+5·0	38	40·5	45	47	53·8	+0·5
7	36	37·5	44·5	51·5	62·0	−1·0	35	37·5	43	49	54·8	+1·2	35	37	41	48	57·6	−0·4
8	33	36	42·5	48·5	56·2	+1·1	40	50·5	56	60·5	66·6	+4·5	36	40·5	46	46	54·4	+1·1
9	40	44	49·5	50	59·4	+0·6	48	56·5	64·5	69·5	71·8	+5·4	41	44·5	48	47	61·6	−1·6
10	44	50	56	58	60·6	+3 6	53	62	70	72	69·8	+6·7	47	50	57	61·5	61·0	+3·4
11	48	51	56	59·5	63·0	+1·8	45	47	54	63	79·2	−1·4	39	40	45·5	52·5	63·6	−0·9
12	32	35·5	40·5	47	64·0	−1·6	33	37	44	51·5	67·6	−0·6	32	36	41	41	54·2	−0·6
13	38	42·5	47	52	62·4	+0·5	44	50	61	61	67·8	+3·6	38	40·5	45	46	56·2	−0·5
14	37	44	49	48·5	60·6	+1·0	44	47·5	59	58	62·2	+3·3	41	45	46	44	59·0	−2·2
15	43	48·5	52·5	57	61·2	+2·5	47	50·5	58	64	70·6	+1·9	46	49·5	54·5	53	62·6	+0·1
16	49	52·5	58	65	71·6	+1·4	51	56	64	69	77·8	+2·1	42	43	48	52·5	69·2	−2·8
17	37	39	44	50	64·2	−1·5	37	45·5	54	56	72·4	+1·5	30	33	41	45	58·8	−0·2
18	34	38	42	47	61·6	−1·0	44	52	58·5	64	66·6	+4·7	44	48	55·5	53·5	64·2	+0·6
19	45	48	56	62	67·0	+2·3	53	58	67	68·5	71·0	+3·9	53	56	63	66	63·6	+3·9
20	46	47	53·5	60·5	69·0	0·0	49	49	56	63·5	79·8	−2·4	36	36	43·5	49	62·4	−1·5
21	31	33·5	42	50	62·2	0·0	34	34·5	42	49·5	64·2	−1·6	32	33	39·5	40	53·6	−1·6
22	34	35	40	46	60·0	−1·9	36	39	46	56	67·4	+0 4	34	35·5	42	40	54·6	−1·8
23	41	45	47	52	64·8	−1·0	46	54·5	60	64·5	70·4	+3·7	44	43	49	48	59·8	−2·2
24	45	49·5	57	58	65·8	+1·8	48	55	63	63·5	74·0	+2·3	45	48	54	50	62·0	−0·6
25	50	53·5	59	62·5	68·4	+1·5	55	62·5	71·5	73	77·6	+4·4	48	51	58	55	64·0	+0·5
26	56	57·5	59	64	71·2	−0·8	57	65·5	73	75·5	80·4	+4·4	50	51·5	59	56·5	70·6	−1·4
27	52	54·5	58	63	71·8	−0·2	55	65	72	74	78·6	+5·0	51	54	61	61	71·0	+0·4
28	52	54	58	63	75·8	−1·4	51	57	63	71·5	78·8	+2·5	47	48	54·5	54	66·6	−1·4
29	53	56	57	65	72·4	−1·8	58	66·5	71	78	77·8	+5·2	54	56·5	63 5	65	68·6	+2·0
30	53	55·5	62	69	69·8	+2·8	55	56·5	64	70·5	74·6	+1·7	52	53·5	60·5	65	69·8	+1·3

The average of the differences shown in this table (paying attention to the algebraic signs) for 7.35 A. M. is +0°·54, for 4.35 P. M. it is +2°·88 and for 11 P. M. it is +0°·05. In six cases we find differences as great as five degrees. These large differences occur only at 4.35 P. M. and appear to depend mainly upon other circumstances than the height of the barometer. The average of all the differences when the barometer on Mt. Washington was considerably below the mean is +0°·84; and the average of all the differences when the barometer was considerably above the mean is +1°·22, showing a difference of only 0°·38 depending upon the height of the barometer on Mt. Washington, and this is only five per cent of the difference shown in table III for the warmest season of the year. We hence conclude that the error arising from assuming that the mean temperature of the air column is equal to the half sum of the temperatures at the upper and lower stations, is quite inappreciable if the observations embrace a considerable period of time and are made at all hours of the day. The observations made on Mt. Washington in May, 1873, and those made in May, 1872, and published in the Report of the Chief Signal Officer for 1872 lead to similar conclusions.

I consider it to be proved that the differences shown in table III between the pressures observed at sea-level and the Mt. Washington observations reduced to sea-level by the tables of Laplace, or Plantamour or Ferrel, are not due in any considerable degree to an error in the assumed temperature of the air column. The question then remains unanswered, what is the cause of these discrepancies? In my fifteenth paper, on page 6 I have given a table of forty cases in which the observed reduction of the Mt. Washington observations to sea-level was 0·30 inch greater than that given by the formula of Laplace. These forty cases are derived from 3285 observations, viz: three daily observations for a period of 36 months, and therefore constitute but little more than one per cent of the entire number of observations. They represent the cases in which the cause or causes which gave rise to the anomalies shown in table III acted with their greatest energy, and they are therefore well adapted to indicate what this cause was. These cases are enumerated in table V, and I have endeavored to free them from certain errors which may have affected the results as published in my fifteenth paper. In each case I have deduced the pressure and temperature at sea level from the observations at Burlington and Portland by the formula $\frac{1}{5}(2B+3P)$, and the results are given in columns three and four. The four succeeding columns are obtained in the manner explained in my fifteenth paper, and the discrepancies are shown in the ninth column under the heading O−C. It will be perceived that these

numbers differ a little from the numbers in my fifteenth paper. The average of the differences given in that paper was 0·36 inch, and the average of the differences in column ninth of table V is 0·35 inch, a change which is unexpectedly small.

TABLE V.—*Cases in which the reduction to sea-level was unusually great.*

No.	Date.	Sea-level. Bar.	Sea-level. Therm.	Mt. Wash'n. Bar.	Mt. Wash'n. Ther.	mean temp.	Lapl'e reduc.	O—C	Bar. by isobars.	O—C	Wind. Direction and velocity.
	1872.										
1	Nov. 7.3	29·26	40°·4	22·78	20°	30°·2	28·98	+·28	29·24	+·26	SE. 4; SW. 38; NW. 65.
2	8.1	·33	41·6	·80	21	31·3	·99	·34	·32	·33	NW. 48.
3	8.2	·44	46 8	·96	22	34·4	29·15	·29	·40	·25	N. 65.
4	9.1	·77	40·6	23·12	19	29·8	·42	·35	·71	·29	NW. 58.
5	9.2	·88	39·8	·24	20	29·9	·57	·31	·85	·28	W. 78.
6	29.2	·72	32·6	22·89	13	22·8	·24	·48	·62	·38	NE. 22; SW. 35.
7	30.1	·45	15·8	·63	5	10·4	·12	·33	·42	·30	NE. 45.
8	30.3	·63	16·2	·73	3	9·6	·26	·37	·60	·34	W. 48.
9	Dec. 1.1	·84	20·6	·85	4	12·3	·37	·47	·81	·44	N. 52.
10	3.2	·80	36·0	23·14	17	26·5	·50	·30	·75	·25	SE 60.
11	4.1	30·01	30·2	·24	14	22·1	·70	·31	·96	·26	SE. 42; W. 58.
12	10.1	29·61	11·8	22·78	3	7·4	·36	·25	·60	·24	SE. 16; W. 59.
13	15.2	·92	30·4	23·12	11	20·7	·57	·35	·96	·39	NW. 23; N. 28; N. 68.
14	22.2	30·17	6·6	·05	— 9	— 1·2	·86	·31	30·18	·32	SW. 65; W. 35; W. 43.
15	24.3	·48	— 8·8	·05	—16	—12·4	·07	·41	·50	·43	[23·2 SE. 32]; W. 44.
16	28.1	29·95	— 1·8	22·75	—20	—10·9	·66	·29	29·93	·27	NE. 60.
	1873.										
17	Jan. 6.2	30·08	25·0	23·14	6	15·5	·68	·40	30·04	·36	S. 60; W. 32; W. 60.
18	11.3	·15	8·2	·06	—11	— 1·4	·88	·27	·17	·29	[9·2 SW. 36]; N. 76.
19	29.1	·22	3·4	·10	— 5	— 0 8	·92	·30	·25	·33	SW. 18; W. 28; W. 54.
20	Feb. 10.1	·10	0·0	22·96	— 4	— 2·0	·76	·34	·16	·40	[7·3 S. 34]; NW. 77.
21	10.2	·07	7·6	23·01	— 5	1·3	·77	·30	·09	·32	NW. 103.
22	Mar. 16.2	29·43	33·0	22·78	11	22·0	·11	·32	29·42	·31	S. 38; SW. 52; W. 28.
23	16.3	·60	27·6	·74	7	17·3	·14	·46	·58	·44	NW. 56.
24	17.1	·79	25·0	·87	4	14·5	·35	·44	·76	·41	W. 56.
25	17.2	·94	29·4	23·15	6	17·7	·66	·28	·94	·28	NW. 25.
26	24.1	·96	14·6	22·92	3	8·8	·52	·44	·97	·45	[21·1 SE. 50]; W. 48.
27	Dec. 10.1	30·09	33·0	23·33	15	24·0	·78	·31	30·06	·28	[7·3 calm]; NW. 62.
	1874.										
28	Apr. 30.2	29·38	38·2	22·67	8	23·1	28·96	·42	29·36	·40	[29·1 E. 35]; NW. 130.
29	30.3	·41	37·2	·72	10	23·6	29·01	·40	·39	·38	NW. 115.
30	Dec. 29.2	·88	26·6	23·02	— 3	11·8	·59	·29	·89	·30	[27·2 N. 20]; NW. 80.
31	30.2	30·21	10·8	·01	—20	— 4·6	·88	·33	30·20	·32	NW. 98.
	1875.										
32	Jan. 9.3	29·94	9·4	22·70	—26	— 8·3	·54	·40	29·96	·42	SW. 73; SW. 50; NW. 100
33	14.1	·78	24·6	·91	0	12·3	·44	·34	·79	·35	SW. 60; NW. 70.
34	14.3	·94	12·6	·82	—20	— 3·7	·61	·33	·95	·34	NW.
35	15.1	30·11	2·6	·71	—33	—15·2	·69	·42	30·12	·43	NW.
36	15.2	·17	5·4	·95	—25	— 9·8	·90	·27	·21	·31	NW.
37	15.3	·21	— 0·2	23·00	—14	— 7·1	·91	·30	·21	·30	NW.
38	17.1	·17	2·0	22·91	—24	—11·0	·86	·31	·22	·36	NW.
39	25.2	29·82	26·6	·93	0	13·3	·45	·37	29·87	·42	[24·2 S. 60]; NW. 80.
40	26.2	30·06	15·2	·95	—15	0·1	·71	·35	30·11	·40	NW. 94.

In some cases, an appreciable error may arise from assuming that the pressure at sea-level under Mt. Washington is given by the formula $\frac{1}{5}(2B+3P)$ and a more accurate value may be derived from the isobars drawn to represent all the observations in the vicinity of Mt. Washington. Column tenth shows the height of the barometer at sea-level under Mt. Washington obtained by this method. These numbers were generally obtained from the isobars drawn on the Signal Service maps, but in a few of the cases I have made a slight change in the position of the isobars when the curves on the Signal Service maps did not appear to have been drawn with sufficient care. Column eleventh shows the differences between the numbers in columns three and ten. The average of the numbers in column eleventh is 0·34 inch. The error in the assumed mean temperature of the air column produces a small effect, but by none of the preceding refinements are the discrepancies to be explained materially changed.

In order to have a graphic representation of the relation of these quantities to the state of the barometer, I have drawn the curves representing the barometric observations on Mt. Washington, and also the curves of pressure at sea-level, for the entire period of the three years which comprehend the observations in tables I and II; and on these curves I have indicated by small black circles, the position of each of the forty cases included in table V. The accompanying chart, plate I, shows such portion of these curves as embrace the cases enumerated. The spaces between the vertical lines represent intervals of eight hours, and the spaces between the horizontal lines represent tenths of an inch of barometric pressure.

From an inspection of these curves we see that each of these forty cases occurred during the prevalence of an area of low pressure about Mt. Washington. Twenty-one of them were coincident with the lowest pressure observed during the prevalence of the low area; nine occurred eight hours after the lowest recorded pressure; and five others followed soon after the preceding, when the barometer on Mt. Washington was rising but had not yet reached the point of mean pressure. Of the remaining five cases, two occurred at a secondary minimum; that is when there was a smaller minimum included within a large area of depression; two other cases preceded by eight hours the minimum on Mt. Washington, but one of them was eight hours and the other sixteen hours later than the minimum at sea-level, and the remaining case coincided with a slight secondary minimum.

Were these cases of low pressure on Mt. Washington accompanied by a cyclonic movement of the winds? In order to decide this question I have examined the direction and veloc-

ity of the winds on Mt. Washington not only at the dates of the forty cases in table V, but also at several of the preceding observations, and the principal results are exhibited in a condensed form in the last column of table V. When only one wind direction is given, it is to be understood as corresponding to the date in column second. When two wind directions are given, the first corresponds to a date eight hours previous to that in column second; when three wind directions are given, the first corresponds to a date sixteen hours previous to that in column second, with the exception of the cases in which the direction of the wind is included in brackets. In these cases the date of the observation immediately precedes the wind's direction. The forty cases shown in table V correspond to twenty-one different areas of low pressure, as was indicated in my fifteenth paper. Two of these storm areas began with a N.E. wind on Mt. Washington; one began with an E. wind; five began with a S.E. wind; four with a S. wind; and six with a S.W. wind. One of the remaining cases was preceded by a calm, and one of those which began with a S.W. wind was also preceded by a calm. In the two remaining cases, the wind, as reported in the tri-daily observations, blew continually from the W., N.W. or N., but its velocity at one of the early observations was considerably less than at the observations immediately preceding and following.

The twelve storms which began with a wind from the N.E.—E.—S.E—or S. are regarded as unquestionably cyclonic; and the six which began with a S.W. wind are regarded as probably cyclonic. In the three remaining cases, one of which began with a calm, and the other two with a comparatively feeble wind from the N. or N.W. the evidence of a cyclonic motion is unsatisfactory unless it is confirmed by other circumstances. I have endeavored to obtain additional evidence bearing upon this question, from observations of the upper clouds made at neighboring stations on the E. and S.E. sides of Mt. Washington; but during the periods in question the upper clouds were generally concealed from view by the lower clouds. The following are the only observations I have been able to find which bear directly upon this question.

		Wind.	Upper clouds.
1872.	Nov. 7.2, Portland, Me..	N.W. 18	S.
1872.	Nov. 30.2, Portland, Me..	S.W. 18	S.
1873.	Feb. 8.1, Portland, Me..	S.W. 12	N.E.
1873.	Mar. 17.2, Portland, Me..	N.W. 18	N.E.
1873.	Mar. 18.1, Portland, Me..	S.W. 8	S.E
1873.	Dec. 9.2, Portland, Me..	S.W. 8	E.
1875.	Jan. 14.2, Eastport, Me..	N. 22	E.

There can be no doubt that the upper clouds here reported had a considerable elevation, which was probably at least equal to that of Mt. Washington, and they indicate a cyclonic motion of the winds about a center but a few miles E. of Mt. Washington. I think then we may safely conclude that in a majority of the cases enumerated in table V, the fall of the barometer on Mt. Washington was due to a cyclonic movement of the winds which prevailed at that elevation. In the remaining cases the observations seem to leave it doubtful whether the fall of the barometer on Mt. Washington was due to a cyclonic movement of the winds which extended to the height of 6000 feet, or was due to a cyclonic movement of the winds which was confined to a lower stratum of the atmosphere. From Plate II accompanying my tenth paper we see that the fluctuations of the barometer on the top of Mt. Washington are often quite unlike those at the base (which is 3387 feet below the summit, and 2898 feet above sea-level), and the fluctuations are sometimes greater in amount. From the plate accompanying this paper we also see similar differences between the barometric oscillations on Mt. Washington, and those at stations in its vicinity near sea-level. According to theory, the fall of the barometer during a cyclonic storm near sea-level should be to the fall on the top of Mt. Washington (the other elements which affect the result being supposed to be the same), in the ratio of the mean pressures at the two stations, i. e. as 29·98 to 23·63 or nearly as five to four. Hence we see that on the summit of Mt. Washington there are frequently cyclonic movements of the wind which are more violent than those at inferior elevations, and this explains in part the anomalies shown in table V. But these anomalies are partly due to the fact that the barometric minima on Mt. Washington generally occur later than they do at sea-level. In several of my former papers I have dwelt upon this subject, and the same fact is clearly indicated by the accompanying plate. The average date of minimum pressure on Mt. Washington is more than eight hours later than it is at sea-level; and there are frequently secondary minima on Mt. Washington which do not occur at sea-level or only in an inferior degree. Hence it results that when the barometer on Mt. Washington stands at its lowest point, the barometer at sea-level has generally risen above the preceding minimum one or two tenths of an inch, and occasionally four tenths of an inch; and at the time of a secondary minimum on Mt. Washington, the barometer at sea-level may have risen three or four tenths of an inch, or even five tenths of an inch more than it has risen on Mt. Washington. Thus on Jan. 15.1, 1875, when the barometer on Mt. Washington was at its lowest point, the barometer at sea-level had already risen

four tenths of an inch: and at the secondary minimum of Dec. 24.3, 1872, the barometer at sea-level had already risen above the preceding minimum a half inch more than the Mt. Washington barometer had risen. A similar case occurred Dec. 30.2, 1874. The discrepancies shown in table V are due partly to the causes here stated, and partly to the violence of the winds on Mt. Washington, for according to theory, the velocity of the wind is the most important factor which determines the depression of the barometer in a great storm.

The excess of the barometric pressure at sea-level above the Mt. Washington observations reduced to sea-level as shown by table III in the case of barometric minima, is ascribed to the same causes.

The differences between the observed and computed reduction to sea-level in the case of barometric maxima shown in table III are explained in a somewhat similar manner. From the accompanying plate, as well as from the plate accompanying my tenth paper, it is seen that generally the date of a barometric maximum is not as distinctly marked as that of a barometric minimum, but the average date of maximum pressure on Mt. Washington is more than eight hours later than it is at sea-level; and when the barometer on Mt. Washington stands at its highest point, the barometer at sea-level has frequently fallen below the preceding maximum, a tenth of an inch or even more.

If we attempt to represent the reduction of the Mt. Washington observations to sea-level by the Laplace formula with modified coefficients, we find that the high pressures require a larger value of the pressure coefficient than the low pressures. Also that the low temperatures require a larger value of the temperature coefficient than the high temperatures. It is not possible therefore to find values for these coefficients which shall represent the observed reduction for all pressures and temperatures. I have sought to obtain values which shall best represent all the observations, and in doing this I have given the observations made near the time of barometric maxima, twice the weight of those made near the time of barometric minima, for the reason that in the former case the winds are more feeble, and the atmosphere probably approaches nearer to the condition of statical equilibrium. With this assumption I have found that the value of the pressure coefficient which best represents the Mt. Washington observations is 60372, and that of the temperature coefficient is $\frac{1}{982}$; indicating that the pressure coefficient employed by Laplace (60158·6) is too small.

I next undertook a similar comparison of the observations on Pike's Peak and Denver. Table VI shows the principal barometric minima on Pike's Peak during a period of three

TABLE VI.—*Barometric minima on Pike's Peak.*

No.	Date.	Denver. Bar.	Denver. Therm.	Pike's Peak. Bar.	Pike's Peak. Ther.	Mean temp.	No.	Date.	Denver. Bar.	Denver. Therm.	Pike's Peak. Bar.	Pike's Peak. Ther.	Mean temp.
	1873.							1877.					
1	Nov22.1	24·56	29	17·43	12	20°·5	49	Jan 15.2	24·64	4	17·21	0	2·0
2	22.3	·92	32	·46	10	21·0	50	21.2	·59	18	·31	1	9·5
3	27.3	·68	22	·56	9	15·5	51	Feb. 7.1	·72	24	·50	— 2	11·0
4	28.2	·62	48	·26	14	31·0	52	Mar. 2.2	·21	46	·25	13	29·5
5	Dec. 2.2	·41	20	·13	5	12·5	53	8.1	·53	32	·25	— 8	12·0
6	3.1	·59	— 2	16·97	—21	—11·5	54	31.1	·23	42	·17	— 3	19·5
7	3.3	·57	3	17·03	—23	—10·0	55	Apr 21.1	·37	50	·30	5	27·5
8	7.3	·49	28	·26	6	17·0	56	22.1	·59	36	·34	2	19·0
9	11.2	·54	26	·27	8	17·0	57	26.2	·68	32	·37	0	16·0
	1874.						58	May 5.1	·54	38	·42	7	22·5
10	Jan. 3.2	·49	19	·11	6	12·5	59	18.1	·31	50	·39	11	30·5
11	21.2	·47	24	·13	— 1	11·5	60	31.1	·33	51	·35	8	29·5
12	22.3	·51	19	·11	—16	1·5	61	June 7.2	·55	49	·57	23	36·0
13	Feb 12.2	·17	31	16·99	1	16·0	62	8.1	·89	42	·61	10	26·0
14	21.2	·74	14	17·13	—12	1·0	63	Jul. 26.3	·62	71	·87	33	52·0
15	22.1	·72	2	·11	—18	— 8·0	64	Sep.13.2	·57	74	·75	32	53·0
16	24.1	·83	— 6	·16	—14	—10·0	65	14.1	·68	53	·69	12	32·5
17	Mar. 3.1	·44	29	·14	3	16·0	66	Oct. 13.2	·58	45	·56	27	36·0
18	6.1	·53	20	·17	—14	3·0	67	17.3	·81	49	·62	13	31.0
19	16.1	·23	31	·16	— 3	14·0	68	27.3	·56	32	·40	8	20·0
20	Apr. 4.2	·56	42	·39	10	26·0	69	Nov. 4.1	·56	28	·45	4	16·0
21	12.2	·55	45	·37	11	28·0	70	7.1	·57	36	·40	0	18·0
22	13.1	·46	42	·38	4	23·0	71	13.1	·48	33	·51	8	20·5
23	16.1	·84	25	·40	— 5	10·0	72	28.2	·70	21	·27	—18	1·5
24	May 2.1	·49	42	·29	— 1	20·5	73	Dec. 3.2	·34	41	·26	4	22·5
25	9.2	·22	56	·25	11	33·5	74	4.1	·63	24	·25	—11	16·5
26	11.2	·78	62	·52	20	41·0	75	5.1	·92	18	·41	—20	— 1·0
27	Jun 10.1	·79	49	·71	22	35·5	76	26.3	·66	27	·32	— 7	10·0
28	Au. 10.1	·67	62	·81	30	46·0		1878.					
29	Sep. 18.1	·76	49	·67	19	34·0	77	Jan. 3.1	·59	7	·32	—11	— 2·0
30	Oct. 24.1	·45	48	·42	10	29·0	78	11.1	·40	33	·38	5	19·0
31	25.1	·76	35	·57	13	24·0	79	29.1	·68	35	·44	— 6	14·5
32	27.3	·54	46	·42	8	27·0	80	Feb. 5.1	·29	35	·32	3	19·0
33	Nov. 4.1	·53	42	·40	5	23·5	81	8.1	·54	29	·29	— 7	11·0
34	7.1	·44	43	·32	3	23·0	82	14.1	·44	30	·29	— 5	12·5
35	22.1	·20	37	·16	0	18·5	83	21.1	·54	30	·37	— 2	14·0
36	23.1	·64	30	·46	— 1	14·5	84	Mar. 1.1	·44	34	·38	6	20·0
37	27.1	·80	22	·47	1	11·5	85	8.1	·16	28	16·99	—18	5·0
38	Dec 15.2	·47	42	·35	7	24·5	86	27.1	·42	36	17·38	10	23·0
39	21.1	·67	14	·27	— 6	4·0	87	29.1	·48	31	·35	5	18·0
40	23.1	·86	14	·33	—13	0·5	88	Apr. 9.1	·48	28	·24	— 4	12·0
41	27.1	·46	11	·16	— 7	2·0	89	15.1	·33	39	·29	3	21·0
42	28.1	·59	9	·24	— 9	0·0	90	17.1	·16	41	·09	— 6	17·5
	1875.						91	May 2.1	·67	44	·56	10	27·0
43	Jan. 4.3	·73	8	·15	— 6	1·0	92	7.1	·73	40	·55	12	26·0
44	6.2	·51	15	·17	— 7	4·0	93	18.1	·49	39	·38	6	22·5
45	8.1	·80	—10	·24	— 2	— 6·0	94	Jun 16.1	·76	56	·79	28	42·0
46	12.2	·64	— 9	·06	— 2	— 5·5	95	July 5.1	·73	63	·91	35	49·0
	1877.						96	Sep. 19.1	·74	51	·75	21	36·0
47	Jan 11.2	·73	10	·27	9	9.5	97	30.1	·46	46	·57	20	33·0
48	14.3	·28	32	·21	2	17·0							

TABLE VII.—*Barometric maxima on Pike's Peak.*

No.	Date.	Denver. Bar.	Denver. Therm.	Pike's Peak. Bar.	Pike's Peak. Ther.	Mean temp.
	1873.					
1	Nov. 4.1	24·80	33	17·89	14	23°·5
2	9.3	25·11	58	18·05	30	44
3	16.2	24·88	66	17·91	26	46
4	Dec 13.3	25·00	10	17·97	2	6
5	24.3	24·95	26	17·91	13	19·5
6	29.3	24·99	22	17·86	12	17
	1874.					
7	Jan. 6.2	24·85	37	17·82	14	25·5
8	24.3	25·13	27	17·88	2	14·5
9	25.2	24·92	51	17·85	18	34·5
10	28.3	24·94	54	17·81	11	32·5
11	Feb. 9.1	24·99	10	17·72	4	7
12	10.2	24·64	53	17·68	16	34·5
13	27.2	24 80	32	17·68	12	22
14	28.3	24·85	30	17·76	3	16·5
15	Mar 22.3	24·92	45	17·77	9	27
16	23.3	25·06	36	17·79	16	26
17	27.2	24·80	56	17·77	15	35·5
18	Apr. 2.2	24·91	55	17·74	9	32
19	10.2	24·75	70	17·79	21	45·5
20	28.3	24·92	62	17·96	19	40·5
21	May 4.2	25·01	64	17·93	24	44
22	18.1	24·92	54	18·03	28	41
23	24.3	24·88	70	18·00	29	49·5
24	Jun 20.2	24·91	93	18·19	48	70·5
25	Jul. 30.2	24·88	84	18·20	54	69
26	Au. 15.3	24·90	81	18·15	41	61
27	Sep. 1.2	24·86	75	18·08	49	62
28	7.1	24·82	54	18·03	35	44·5
29	27.3	24·99	57	18·09	29	43
30	Oct. 9.2	24·95	76	18 07	29	52·5
31	16.3	25·01	50	18·04	24	37
32	22.2	24·96	72	18·06	32	52
33	Nov. 1.1	24·96	29	17·84	12	20·5
34	12.2	24·90	56	17·85	22	39
35	29.1	24·98	47	17·89	15	31
36	Dec. 2.3	24·92	37	17·87	14	25·5
37	5.3	25·20	31	17·95	11	21
38	6.2	25·02	61	17·96	18	39·5
	1875.					
39	Jan. 1.3	24·91	22	17·59	1	11·5
40	2.3	24·72	39	17·53	4	21·5
41	19.2	24·56	40	17·59	17	28·5
42	21.3	24·84	15	17·55	— 5	5
	1877.					
43	Jan. 3.2	24·92	46	17·79	9	27·5
44	24.1	25·07	0	17·83	7	3·5
45	27.1	25·07	14	17·84	5	9·5
46	Feb. 1.3	24·89	33	17·82	13	23
47	17.1	25·00	25	17·84	8	16·5
48	19.3	25·04	35	17·87	10	22·5
49	Mar 14.3	24·85	60	17·90	23	41·5
50	17.3	24·88	48	17·84	13	30·5

No.	Date.	Denver. Bar.	Denver. Therm.	Pike's Peak. Bar.	Pike's Peak. Ther.	Mean temp.
	1877.					
51	Mar 25.3	24·81	52	17·84	17	34°·5
52	26.3	24·74	57	17·81	21	39
53	Apr. 5.3	24·66	56	17·69	14	35
54	23.3	24·96	37	17·69	10	23·5
55	M'y 24.1	24·87	53	17·88	22	37·5
56	27.1	24·78	51	17·91	25	38
57	Jun 16.3	24·77	73	18·03	32	52·5
58	21.3	24·83	69	18·09	33	51
59	July 5.1	24·92	65	18·17	39	52
60	9.2	24·94	83	18·14	39	61
61	Au. 10.3	24·96	70	18·15	39	54·5
62	29.1	24·94	57	18·17	40	48·5
63	Sept. 1.1	25·00	55	18·12	35	45
64	7.1	24·90	58	18 05	29	43·5
65	10.1	24·89	53	18·05	39	46
66	20.1	24·90	47	18·05	30	38·5
67	Oct. 7.3	24·88	50	17·92	21	35·5
68	9.2	24·87	68	17·98	31	49·5
69	10.1	24·94	38	18·02	26	32
70	Nov. 9.3	24·90	36	17·92	18	27
71	10.2	24·84	54	17·92	22	38
72	16.1	24·93	49	17·89	16	32·5
73	Dec. 7.3	24·98	30	17·89	14	22
74	9.3	24·89	37	17·92	20	28·5
75	10.3	24·89	37	17·98	18	27·5
76	12.3	25·13	35	17·96	10	22·5
	1878.					
77	Jan 10.1	24·71	21	17·70	8	14·5
78	16.1	24·72	17	17·69	5	11
79	21.1	24·95	15	17·73	— 4	5·5
80	27.1	24·74	26	17·63	2	14
81	Feb. 4.1	24·72	32	17·70	8	20
82	18.1	24·69	39	17·66	12	25·5
83	26.1	24·77	17	17·69	7	12
84	Mar 16.1	24·97	34	17·88	16	25
85	21.1	24·90	35	17·88	17	26
86	24.1	24·86	40	17·89	12	26
87	Apr. 5.1	24·72	39	17·77	16	27.5
88	25.1	24·80	35	17·75	10	22·5
89	29.1	24·74	43	17·78	22	32·5
90	May 9.1	25·09	44	17·89	15	29·5
91	10.1	24·98	37	17·87	14	25·5
92	24.1	24·89	45	17·88	20	32·5
93	Jun 15.1	24·99	55	18·02	34	44·5
94	19.1	24·93	55	18·05	35	45
95	22.1	24·84	61	18·08	33	47
96	Jul. 13.1	25·01	67	18·22	38	52·5
97	21.1	24·94	65	18·14	40	52·5
98	Aug. 1.1	24·96	67	18·20	44	55·5
99	3.1	24·93	63	18·17	48	55·5
100	24.1	24·95	70	18·17	41	55·5
101	Sept. 2.1	24·97	60	18·16	36	48
102	26.1	25·02	39	18·00	27	33

years, and the observations are arranged in the same manner as in table I. Table VII shows the principal barometric maxima on Pike's Peak during a period of three years.

The numbers in each of these tables were divided into four equal groups, and the average of the numbers in each group was taken. The results are given in the first five columns of table III, and the numbers in the other columns were computed in the same manner as has been explained for Mt. Washington.

We see that for barometric minima, the differences between the observed reductions to sea-level and those computed by the Laplace formula are quite small, while for barometric maxima they are quite large; but when the computations are made by Ferrel's tables the average difference between theory and observation is almost exactly the same in both cases, with the exception of the algebraic signs. These results accord with those for Mt. Washington in indicating that the pressure coefficient in the Laplace formula is too small. The value of the pressure coefficient which best represents the Pike's Peak observations is 60357, and that of the temperature coefficient is $\frac{1}{1009}$. For barometric minima, the average difference between the observed reduction and that computed by Ferrel's formula is less than half of that found for the Mt. Washington observations, a result which may be ascribed, at least in part, to the feebler winds which prevail on Pike's Peak.

For barometric maxima, the differences for Pike's Peak computed by Ferrel's formula are greater than for Mt. Washington, and for the lowest temperatures they are more than twice as great. We have found for Mt. Washington, three causes for these discrepancies: 1, an erroneous assumption with regard to the mean temperature of the air column; 2, a retardation in the date of barometric maximum at the upper station; and 3, small changes of pressure at one of the stations which are not felt (or in a less degree) at the other station. I know of no observations which indicate what effect may be ascribed to the first of these causes in the present case, but probably the effect is small. The effect due to the second cause is often quite large. The barometer at Denver (after a maximum) generally begins to fall from eight to sixteen hours sooner than on Pike's Peak, and it sometimes falls a quarter of an inch or more before the descent begins at Pike's Peak. Thus Dec. 13.3, 1873, after an uncommonly high pressure, the barometer at Denver fell ·28 inch before the barometer at Pike's Peak began to fall. Again Jan. 14.1, 1874, the barometer at Denver was at a maximum, from which time it fell for four days uninterruptedly with the exception of two slight reactions, one amounting to ·01 inch and the other to ·04 inch. The barometer at Pike's Peak did not begin to fall until after Jan. 16.1, when the

barometer at Denver had already descended ·43 inch. A similar case occurred between April 8 and April 10, 1874. This cause of the discrepancies between the observed and computed reductions, seems to be more efficient for Pike's Peak than for Mt. Washington. The third cause above mentioned affects the observations on Pike's Peak, but in general the curve of pressure for Pike's Peak is much less jagged than for Denver. The barometer on Pike's Peak frequently remains above its mean height for several days—sometimes a week or ten days—with only small fluctuations, while during the same period at Denver there have been numerous maxima and minima of considerable magnitude. Thus it sometimes happens that a barometric maximum on Pike's Peak occurs nearly, if not exactly, at the time of a barometric minimum at Denver.

[To be continued.]

ART. II.—*Light of Comparison Stars for Vesta;* by EDWARD C. PICKERING.

IN Professor Harrington's important "Study of Vesta," which appeared in this Journal, III, xxvi, 461, the light of the planet was determined from comparisons with the two stars DM. +22° 2163 and 2164. The observations were made with the wedge photometer, and were accordingly differential, so that the resulting magnitudes of Vesta depend upon the assumed magnitudes of the stars, which were taken from the Durchmusterung. It therefore appeared desirable that the stars should be observed with the large meridian photometer of the Harvard College Observatory, with the object of providing means for the reduction of Professor Harrington's results to absolute measures. The meridian photometer has been described in the Monthly Notices of the R. Astron. Society, xlii, 365.

The following table exhibits the results respectively obtained for the two comparison stars. The first column contains the numbers of the series to which the observations belong, the second the dates, and the third the initials of the observers, E. C. Pickering and O. C. Wendell. The fourth and fifth columns contain residuals expressed in tenths of a magnitude. The mean results, from which these residuals are derived, when corrected for atmospheric absorption, are 9·06 for DM.+22° 2163 and 5·48 for DM.+22° 2164. The fifth observation of DM.+22° 2163 was rejected because it appeared that an error of 30° in reading the graduated circle of the photometer had probably occurred in one of the four comparisons which constitute a complete observation with the meridian photometer. The residual corresponding to the rejected observation is placed in brack-

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ets. If the presumed error of 30° is left without correction, this residual would become −0·9 instead of −0·2. The separate reduction of the four comparisons gives the residuals −2·4, 0·0, −0·5, +0·1. Correcting the first reading by 30°, its residual is reduced to −0·3.

No. of Series.	Date, 1884.	Obs.	Residuals 2163	2164
249	March 16	P.	−0·1	0·0
251	March 18	W.	0·0	0·0
252	March 22	P.	0·0	−0·1
254	March 25	W.	+0·1	+0·1
255	March 31	P.	[−0·2]	−0·2
261	April 14	P.	+0·1	+0·2

The corrections to be applied to the DM. magnitudes of the stars appear from these observations to be +·28 for DM.+ 22° 2163 and+ ·18 for DM. +22° 2164. From these corrections may be derived the formula $M-m=\cdot 023m+\cdot 058$, in which M denotes the photometric magnitude of Vesta corresponding to the magnitude m given by Professor Harrington.

In the following table the first column is repeated from Professor Harrington's table in the article above mentioned. The second column contains the corresponding magnitudes of Vesta computed for mean opposition, after correction by the formula just obtained. By mean opposition is understood, as usual, the situation in which a planet is in exact opposition to the Sun, while both the planet and the Earth are at their mean distances from the Sun. The third column contains the residuals from the mean, 6·64, of the corrected magnitudes thus found. The last column contains the residuals showing the accordance of Professor Harrington's observations of the two comparison stars. Taking the differences between the two columns of his table headed 2164 and 2163, we have a series of quantities expressed in seconds of time, the mean of which is 20·6; it corresponds to the photometric difference in magnitude resulting from the observations made here with the meridian photometer. This photometric difference is 9·06−5·48 = 3·58. These data show that in Professor Harrington's observations one second of time may be expressed in terms of magnitude by ·174. The final column of the table here given accordingly contains the products by ·174 of the differences between Professor Harrington's columns 2164 and 2163, diminished by the photometric difference 3·58. If reduced to the equator, the quantity ·174 becomes ·16, which furnishes a determination of the constant of reduction required by the particular wedge employed. The last line of the table contains the numerical means of the quantities in the last three columns. It may be observed that in the first and third lines of the table the large residuals in the third column are accompanied by large residuals in the final

column and are therefore partly attributable to errors of observation. In the seventh line from the end of Professor Harrington's table, 5·84 is assumed to be a misprint for 6·84.

Sidereal time of Observation. April, 1888. d.	h.	m.	Magn. of Vesta.	Residuals. Vesta.	Stars.
9	XII	17	7·21	+·57	−·24
13	XII	31	6·59	−·05	+·05
	XIV	57	6·17	−·47	−·26
	XV	24	6·39	−·25	−·19
15	XII	38	6·55	−·09	+·02
	XIII	19	6·43	−·21	+·07
	XV	43	6·32	−·32	−·14
16	X	3	6·73	+·09	·00
	XI	55	6·85	+·21	+·03
	XII	26	6·43	−·19	+·14
	XII	55	6·78	+·14	+·11
	XIII	24	6·69	+·05	−·14
	XIII	49	6·79	+·15	−·12
	XIV	18	6·79	+·15	+·05
17	IX	39	6·52	−·12	+·09
	X	11	6·47	−·17	+·12
	X	40	6·48	−·16	+·11
	XI	5	6·75	+·11	−·03
	XI	29	6·51	−·13	+·12
	XI	50	6·52	−·12	+·14
	XII	11	6·61	−·03	+·02
	XII	31	6·62	−·02	−·22
19	XII	41	6·67	+·03	−·02
23	XII	8	6·82	+·18	+·07
	XII	58	6·85	+·21	+·17
26	XI	55	6·91	+·27	−·02
28	XII	27	6·84	+·20	+·03
			6·64	±·17	±·10

The mean result for the magnitude of Vesta, 6·64, may be compared with the results formerly obtained at this Observatory and published in the Astronomische Nachrichten, cii, 151. The value obtained from observations on 12 nights in 1880 was 6·49, and from observations on 10 nights in 1881–2 was 6·45. The differences between these values and that derived from Professor Harrington's observations do not seem large, considering the fact that the two methods of observation were very dissimilar. In measuring large intervals of brightness with the wedge photometer systematic errors may perhaps result from irregularities in the tint of the glass and other causes. On the other hand, the small meridian photometer used in the observations of Vesta was not designed for measuring the light of objects fainter than the sixth magnitude, and even the brightest asteroids were seen in the instrument with some little difficulty.

The magnitude 6·51 found for Vesta in vol. xi of the Annals of this Observatory, page 294, was obtained by an indirect process, and its close agreement with the later results just mentioned is probably accidental.

Harvard College Observatory, Cambridge, Mass., May 19, 1884.

ART. III.—*Mineralogical Notes from the Laboratory of the U. S. Geological Survey;* by F. W. CLARKE and T. M. CHATARD.

THE following analyses of minerals have been executed by us in the laboratory of the U. S. Geological Survey, during the past few months. Some of them possess more than ordinary interest, and all have value sufficient to warrant putting them on record. The only novelty in the methods of analysis has been in the determinations of the alkalies. These determinations were made by a modification of Hempel's process for decomposing silicates by fusion with bismuth oxide. An account of the process, as improved and used in this laboratory, will in due time be published.

1. JADE AND PECTOLITE.

Among the Eskimo implements collected by the U. S. Signal Service at Point Barrow, Alaska, were a considerable number of a material which appeared to be jade. Of these there were two varieties; one pale apple-green, the other dark green; both were highly polished, and exceedingly compact and tough. The sp. gr. of the pale green variety was 2·873, that of the dark material was 3·012. Analyses (Clarke) gave results as follows:

	Pale-green.	Dark-green.
Water	4·09	1·41
Silica	53·94	57·01
Ferrous oxide	*trace.*	6·95
Lime	32·21	12·75
Magnesia	1·43	21·36
Alumina	·58	.42
Soda	8·57	----
	100·82	99·90

The dark-green material is plainly jade, or nephrite, quite analogous in composition to that from the Swiss Lake-Dwellings. The light green mineral, on the other hand, agrees in composition with pectolite. It is easily fusible, and has, in short, all the essential properties of pectolite. It is, therefore, a new and interesting variety of that well-known species.

The Eskimo of Point Barrow say that the jade and jade-like minerals used by them come from some point to the eastward. The locality itself, we believe, has not yet been visited by civilized men. Whether both minerals are found at the same place or not, cannot be stated; but we hope that before long, more definite information may be secured.

2. Saussurite.

From a euphotide collected by J. S. Diller, U. S. Geol. Surv., thirty-seven miles north of Pitt River Ferry, Shasta County, California. The mineral is nearly white, with a greenish-gray cast, and has a sp. gr. of 3·148. As the rock itself will be described by Mr. Diller, only the analysis of the saussurite need be cited here.

Analysis, F. W. Clarke.

Ignition	2·42
Silica	42·79
Alumina	29·43
Lime	18·13
Ferrous oxide	3·65
Soda	2·51
Magnesia	1·40
	100·33

3. Allanite.

From Sprague's granite quarry, Topsham, Maine. Abundant in slender black prisms, usually rusty upon the surface, which are known to the local quarrymen as "nails."

Analysis, F. W. Clarke.

Ignition	4·13
Silica	34·97
Alumina	12·83
Ferrous oxide	18·11
Manganous oxide	2·82
Cerium, lanthanum and didymium oxides	17·26
Lime	7·21
Magnesia	1·40
	98·73

The ferrous oxide carries with it some ferric oxide. As the analysis was made merely for the complete identification of the species, the troublesome separation of the cerium group oxides was not considered necessary. The mineral appears to vary considerably in different parts of the quarry.

4. Damourite.

Two specimens of a micaceous mineral from the topaz locality at Stoneham, Maine, collected by Mr. N. H. Perry of South Paris, and sent by him to the National Museum, have been examined and prove to be different forms of damourite.

A. Subfibrous compact, light grayish green in color, greasy luster, associated with albite and topaz.

B. Broadly foliated micaceous, light grayish green, strong mother-of-pearl luster, also associated with topaz. Analyses (Chatard) as follows:

	A.	B.
Ignition	4·48	4·78
Silica	45·19	45·34
Alumina	33·32	33·96
Ferrous oxide	4·25	3·96
Manganous oxide	0·58	0·51
Lime	*tr.*	0·22
Magnesia	0·36	0·10
Soda	1·57	1·49
Potash	11·06	10·73
	100·81	101·09

5. MARGARITE.

B. From Soapstone Hill, near Gainesville, Ga. Bright pistachio green, subfibrous aggregate of extremely minute scales surrounding and radiating from a core of bright rose-pink corundum which is in places interlaminated by the margarite. A very handsome specimen on account of the contrast of color. From Mr. Theodore Moreno of Gainesville, Ga. G. = 3·00; H. = 3·5. Analysis, T. M. Chatard:

Ignition	4·88
Silica	31·72
Alumina	50·03
Ferrous oxide	*tr.*
Lime	11·57
Magnesia	0·12
Alkalies (principally soda)	2·26
	100·58

B. An altered crystal of corundum from Iredell Co., N. C., showing a core of corundum surrounded by a yellowish white, semi-micaceous, compact mineral more or less intermixed with small needles of black tourmaline. Analysis (Chatard) shows the micaceous mineral to be a margarite similar to that described, by Dr. F. A. Genth, as occurring at Hendrick's Farm in the same county.

Ignition	5·68
Silica	31·15
Alumina	49·51
Lime	11·13
Magnesia	0·45
Alkalies (mainly soda)	2·74
	100·66

6. Cimolite?

Among a collection of Maine minerals received from N. H. Perry of South Paris, were several specimens of tourmaline and albite encrusted with a pink to rose-purple, earthy, alteration product. The color was found to be due to a little manganese, which was not, however, separately estimated. The analysis (Clarke), gave results approaching to those required by the rational formula $AlH_3(SiO_3)_3$, as the subjoined figures show.

	Found.	Theory.
Water	9·53	10·4
Silica	70·06	69·8
Alumina*	17·19	19·8
Soda	2·28	
Magnesia	·80	100·0
	99·86	

It will be observed at once that these results do not agree exactly with those commonly obtained for cimolite. They are too high in silica, and too low in water, and the formula deduced from them is somewhat novel. We are inclined to place the mineral, however, under cimolite, as being nearer to that species than to any other. Possibly the new formula represents the final outcome of an alteration process which ordinary cimolite has only partially undergone. Somewhat similar pink alteration products are not uncommon in the albitic granite veins of Maine and New Hampshire, and some, without analysis, have been supposed to be montmorillonite like that of Branchville, Conn. A more thorough examination of such products is much to be desired. The specimens now reported upon came from Norway, Maine.

7. Halloysite.

Collected by Ensign J. B. Bernadou, at the Detroit Copper Mine, near Mono Lake, California. The specimens consisted of irregular lumps, covered and seamed with a black coating of the oxides of copper and manganese. The color of the pure mineral was white, with a very faint tinge of blue. Analysis by F. W. Clarke.

Water	18·95
Silica	42·91
Alumina	38·13
	99·99

* Including a little manganese.

8. Prochlorite.

A dark-green chlorite collected by Mr. G. P. Merrill on Foundry Run, Georgetown, D. C., may be assigned to the above-named species. The mineral is very dark in color, scaly-crystalline, and occurs in quite fine specimens.

Analysis, F. W. Clarke.

Water	14·43
Silica	25·45
Magnesia	15·04
Alumina	17·88
Ferrous oxide	24·98
Soda	·67
	98·45

The iron was all reckoned as ferrous iron, although a little of it is probably ferric.

9. Halotrichite.

At the headwaters of the Gila River, about forty miles north of Silver City, New Mexico, is a deposit of aluminous sulphates which are said to cover some two thousand acres. Among a lot of specimens recently received from this locality was one consisting of white, silky, asbestiform fibers, which were readily soluble in water. The analysis (Clarke) gave results which place the mineral under or near halotrichite.

Water	40·62
Sulphuric acid (SO_3),	37·19
Ferrous oxide,	13·59
Alumina	7·27
Insoluble	0·50
	99·17

A very little of the iron, but not enough to estimate, was in the ferric state. The mineral is reported to be abundant.

10. Alunogen.

Associated with the halotrichite at the foregoing locality are great quantities of alunogen. The specimens received at this laboratory were crusts of various colors, white, pinkish, yellowish, brown and drab. Most of them contained sulphates of iron in small quantities; but one sample of pink color, was free from such impurities.

Analysis, F. W. Clarke.

Water	42·56
Sulphuric acid	34·43
Alumina	15·52
Insoluble	7·62
	100·13

The following minerals from new localities have also come under our observation, and may be properly noted here.

Vivianite from Washington, D. C. Found abundantly in a bed of blue clay, during excavations for the foundation of a building on Connecticut Avenue. The mineral occurs in blue, earthy masses.

Hyalite from Foster's mica mine, near Jefferson, Ashe County, N. C. In very fine stalactitic form, coating the under side of a quartz shelf in a broad granite vein. The specimens are tinted with ferric oxide, and are as fine as any yet noted in this country.

Beryl from Gilmore's mica mine, in Montgomery County, Md., twelve miles north of Washington. Abundant, but not well crystallized, and associated with albite, large plates of muscovite, quartz, garnet and black tourmaline.

Cassiterite from the Brewer Gold Mine, Chesterfield County, S. C. Found in some quantity in the "black sands" of the gold washing, and crystals of $\frac{1}{2}''$ in diameter have been collected. The larger crystals are dark colored, while the small ones are often pale brown, straw-yellow and even colorless. The latter in microscopic grains.

Washington, April 14, 1884.

Art. IV.—*On the occurrence of Alkalies in Beryl;* by Samuel L. Penfield.

My attention was first called to the occurrence of alkalies in beryl, by the detection of cæsium in the qualitative analysis of an unknown silicate from Norway, Maine, resembling in outward appearance a specimen of poorly cleavable feldspar. A quantitative analysis was made in which the presence of beryllium was not suspected, and it was not till the results of the analysis failed to yield any satisfactory formula, that a further examination was made and the mineral was proved to be beryl. In calculating the first analysis the small quantity of alkalies, five per cent in all and more than half cæsium, and the great preponderance of sesquioxides made it probable that the mineral was either impure or that some protoxide was present which the alkalies could be regarded as replacing.

Sections of the mineral when examined with the microscope showed that the material was homogeneous, while beryllium suggested itself as an element which might have been overlooked and weighed with the alumina. As soon as this possibility suggested itself to me, I observed that the specimens in many respects resemble beryl. A more or less perfect basal and a very imperfect prismatic cleavage had previously led me to believe that the mineral was hexagonal and a qualitative analysis proved that beryllium was present in large quantity. The analysis was then repeated, using however better material which had in the mean time come to hand.

After finding alkalies in one beryl it seemed to be of interest to test others from various localities. The result has been to show that, as far as tested, they always contain alkalies, although sometimes only in small quantities. Sodium and lithium were always present, cæsium occasionally, while potassium and rubidium were never detected.

To prove if possible that the alkalies in beryl replace beryllium, as well as to find to what extent they are present, a series of quantitative analyses were made, the results of which are given below. I regret very much that the time at my disposal has been limited, and that I could not first have devoted some time to devising a method for the separation of beryllium and aluminum or for determining the errors which would be involved by a certain definite procedure. I will state here that I shall certainly improve the first opportunity which presents itself for investigating this subject further, and I shall hope to be able to add to the value of this article by giving more correct data as to the percentages of beryllium and aluminum. As the chief interest seemed at first to lie in the detection and determination of the alkalies, I proceeded with the analyses and I will give here the results of them. I add also a full description of the methods employed, so that a proper value may be attached to the beryllium and aluminum determinations.

The mineral was fused with sodium carbonate and the silica separated and weighed according to the usual methods; it was in all cases tested with hydrofluoric acid and the small residue added to the oxides. The beryllium, aluminum and iron were precipitated together with ammonia, filtered and washed, the precipitate dissolved, reprecipitated with ammonia, thoroughly washed and weighed. After weighing, the oxides were dissolved in hydrochloric acid and the solution evaporated on the water bath till the free acid was driven off; the chlorides were then dissolved in a little water, filtered into a flask containing about 125–150 c. c. of a cold saturated solution of ammonium carbonate and some undissolved carbonate, and the slight residue of silica, after washing, weighed, tested as to purity

with hydrofluoric acid and added to the first weight of silica. The flask containing the ammonium carbonate precipitate was shaken from time to time, then allowed to stand for twenty-four hours and the alumina filtered and washed with a nearly saturated cold solution of ammonium carbonate. The precipitate of alumina was dissolved in hydrochloric acid, filtered from the filter-paper, evaporated on the water bath to expel the free acid and precipitated again in the same way to separate the beryllium more completely. After the second separation the alumina, together with the small quantity of iron, was dissolved in hydrochloric acid, precipitated with ammonia, filtered and weighed. The ammonium carbonate filtrates from the alumina, containing the beryllium, were evaporated in platinum dishes on the water bath to expel the great excess of ammonium carbonate and the beryllium dissolved in hydrochloric acid precipitated with ammonia, filtered and weighed. Sometimes the two filtrates containing the beryllium were precipitated together, sometimes separately; when so, about one per cent of beryllium was found to be extracted by the second separation. The sum of the weights of the alumina, beryllium and iron oxides after the separation agreed closely with the first weight of total oxides. The alumina and iron oxides were dissolved in hydrochloric acid, and after being converted into sulphates and reduced, the iron was determined by means of permanganate of potash. The error involved in this method of separation of beryllium from aluminum is generally regarded to be that the ammonium carbonate solution containing beryllium is a solvent for aluminum. I therefore worked with small volumes to decrease as much as possible the amount of alumina which would go into solution and repeated the separation. The error thus involved can only be determined by repeating the operation on solutions containing known quantities of beryllium and aluminum, and I hope to be able to make the necessary determinations at some future date.

The small quantity of iron exists probably in both states of oxidation, replacing both aluminum and beryllium. The protoxide was determined separately in one analysis only, (analysis V). Beryl is very hard to decompose, even with strong hydrofluoric acid; it was necessary to use the finest, elutriated powder and then a complete solution of the mineral, for titration with permanganate, could not be obtained. As the very small quantity of iron in the other beryl can affect the results but very slightly, and as two-thirds of the iron in analysis V was found to exist as protoxide, I have calculated it as such in the remaining analyses.

Tests were always made for calcium and magnesium, but in only two analyses could they be detected. Great care was taken

in the determination of the alkalies. The mineral was in all cases decomposed by long treatment with pure hydrofluoric acid, the bases being converted into sulphates. From the solution the beryllium oxide and alumina were precipitated with ammonia and the alkalies weighed as sulphates. Care was taken to avoid as much as possible the use of glass and all the evaporations were carried on in platinum. In the last analyses where it was known that the amount of alkalies would be very small, the beryllium oxide and alumina were precipitated in platinum dishes, and the only glass with which the solutions were in contact were the glass funnels used in filtering off the precipitates; care was also taken to use water which had not stood long in wash bottles. The sulphates of the alkalies after weighing were converted into chlorides, and the lithium separated by means of alcohol and ether and weighed as sulphate. The cæsium was precipitated and weighed as cæsium platinic chloride. After weighing it was tested carefully with the spectroscope for potassium and rubidium, but neither could be detected.

The loss by ignition is considerable, as will be seen by the analyses. That water is contained in perceptible quantity can be readily seen by heating the mineral very intensely in a closed glass tube. The loss by ignition does not in all cases represent the water chemically combined in the mineral, because liquid inclusions are readily seen in the beryl from Branchville and may be contained in others. The water reacts neutral or only slightly acid to test papers, (the acid reaction probably due to carbon dioxide). It is not completely given off except by very strong ignition. By strong ignition over a blast lamp in a covered crucible no sublimate collected on the lid of the crucible. The powder usually sinters together to a porous cake and this behavior affords an indication of the presence of alkalies, those containing much alkali sintering together to a firm porous mass, while those containing very little as in analyses VI and VII, left a mass which could be readily crushed to powder between the fingers.

Chlorine, fluorine, boracic and phosphoric acids could not be detected.

The varieties which have been analyzed are the following, arranged according to the amount of alkali which they contain. The specific gravities were taken in water of the ordinary laboratory temperature, on a chemical balance, and are given with the analyses.

I. From Hebron, Maine. The material was taken from a fragment of a very much cracked, colorless crystal imbedded in lepidolite and was given to me by Professor O. D. Allen, who collected it at the locality. Care was necessary in select-

ing enough pure and clear material for the analysis. It is interesting in showing that the beryl contains much more cæsium than the lepidolite in which it is imbedded.

II. From Norway, Maine. The material was milk-white, and did not outwardly resemble beryl, the fragments in my possession showing no crystal faces. It was collected by Mr. N. H. Perry of South Paris, Me., and sent to Professor George J. Brush, who kindly gave me the material for analysis.

III. From Branchville, Conn. The material was taken from a fragment of a large crystal of a beautiful pale, sea-green color, much resembling a piece of slightly colored quartz.

IV. From Amelia Court House, Virginia. The material was taken from a large milk-white crystal in the collection of Professor Brush.

V. From Royalston, Mass. From a bluish green crystal, from which pure transparent material could readily be obtained.

VI. From Stoneham, Maine. The material was perfectly transparent and taken from fragments of a crystal of a pale green color furnished by Mr. George F. Kunz, of New York.

VII. From Aduntschilon, Siberia. The transparent crystals of a pale green color were taken from a specimen in the collection of Professor George J. Brush. The specimen was sent to him by Mr. J. von Eichwald, who collected it at the locality.

	I. Hebron, Me.	II. Norway, Me.	III. Branchville, Conn.	IV. Amelia Co., Va.	V. Royalston, Mass.	VI. Stoneham, Me.	VII. Aduntschilon, Siberia.
SiO_2	62·10	64·29	64·74	65·13	65·14	65·20	66·17
Al_2O_3	18·92	18·89	20·13	20·80	19·83	20·25	20·39
					Fe_2O_3 ·44		
FeO	·49	·48	·54	·49	·78	·66	·69
BeO	10·35	10·54	10·26	11·03	11·32	11·46	11·50
Cs_2O	2·92	1·66	----	----	----	----	----
Na_2O	1·82	1·39	1·45	·46	·51	·49	·24
Li_2O	1·17	·84	·72	·13	·05	trace	trace
Ign	2·33	2·44	2·69	2·19	2·04	2·08	1·14
	CaO ·35				MgO ·34		
	100·45	100·53	100·53	100·23	100·45	100·14	100·13
Sp. gr.	——	2·744	2·732	2·685	2·711	2·708	2·676

Below I have given the quotients obtained by dividing the percentages by the molecular weights of the constituents arranged in the same order as the analyses. I have regarded the alkalies as replacing the beryllium in all cases, and they are included with the beryllium in protoxides.

Ratio	I.	II.	III.	IV.	V.	VI.	VII.
SiO_2	1·0350	1·0715	1·0790	1·0855	1·0857	1·0866	1·1028
Al_2O_3	·1837	·1834	·1954	·2019	·1952	·1966	·1980
Protoxide	·4995	·4845	·4653	·4597	·4735	·4755	·4735
Water	·1294	·1355	·1494	·1217	·1133	·1155	·0633

Disregarding the water we should have, according to the usually accepted formula for beryl, $Al_2Be_3Si_6O_{18}$, $SiO_2 : Al_2O_3 : BeO = 6 : 1 : 3$. As silica is probably the most accurately determined of any of the constituents, one-sixth of its quotient can be taken as unity and the ratio of the sesquioxides and protoxides is as follows:

	I.	II.	III.	IV.	V.	VI.	VII.
SiO_2	6·00	6·00	6·00	6·00	6·00	6·00	6·00
Al_2O_3	1·06	1·03	1·08	1·11	1·08	1·08	1·08
Protoxides	2·90	2·71	2·59	2·54	2·62	2·62	2·58

It will be seen that the alumina is in all cases too high and the protoxides too low. The latter might indicate that part or all of the water is basic, replacing the beryllium, and in all but the last analysis there is more than enough water, if calculated as replacing the protoxides, to bring up the ratio to 6 : 1 : 3. If the error in the separation of aluminum and beryllium is, as it is said to be, that the alumina is too low, the excess of that constituent in all the analyses cannot be explained if we accept the present formula.

As regards the water, it certainly cannot be called accidental, for it is always present in amounts varying from 1·50 to 2·50 per cent. It is also given off completely only by very strong ignition, as the following table will show, indicating that it is very firmly united in the molecule. The table is arranged as follows: 1st. Loss by drying for one hour at 100° C. 2d. By igniting for fifteen minutes at a faint red heat, so that the bottom of the crucible only was red. 3d. By igniting for fifteen minutes at a full red heat. 4th. By igniting for fifteen minutes at the full heat of a ring burner. 5th. By heating for five minutes over a blast lamp.

	Loss at 100°	low red	full red	white heat	blast
Hebron, Me.	0·12	0·43	0·84	1·65	2·33
Norway, Me.	0·12	0·42	1·37	1·73	2·44
		0·42	1·49	1·78	2·44
Branchville, Conn.	0·10	0·55	1·54	2·62	2·69
Amelia, Virginia	0·10	----	1·58	2·10	2·19
Royalston, Mass.	0·00	----	1·54	2·00	2·04
Stoneham, Me.	0·08	----	1·68	2·02	2·08
Aduntschilon, Siberia	0·06	----	0·82	1·10	1·14

With the exception of analyses I and II it will be seen that the ratio of $SiO_2 : Al_2O_3$: protoxides is nearly 6 : 1 : 2·5, and there is also in all cases water enough to make the ratio of $SiO_2 : Al_2O_3$: protoxides : $H_2O = 6 : 1 : 2·5 : ·5$ or 12 : 2 : 5 : 1. As we cannot disregard the water entirely, this would seem to be a plausible ratio giving the formula $Al_4Be_5H_2Si_{12}O_{36}$. A compound of the above composition would require the following percentages: SiO_2 67·36, Al_2O_3 19·27, BeO 11·69, H_2O 1·68 = 100·00.

Comparing these percentages with the analyses, remembering that there some beryllium is replaced by alkalies and iron protoxide, we notice that the silica is in all cases too low and the alumina too high, as will be seen best by comparison of the ratios where $SiO_2 : Al_2O_3$ was in all cases near 6 : 1·08. If we regard beryl as a little less acid, containing one less SiO_2 than in the above formula we obtain the formula $Al_4Be_5H_2Si_{11}O_{34}$ equal to $2Al_2(SiO_3)_3$, $5BeSiO_3$, HO_2. This formula, although not so simple as the one at first proposed, agrees much closer with the results of analysis. The percentages corresponding to the formula are SiO_2 65·41, Al_2O_3 20·42, BeO 12·39, H_2O 1·78=100·00. The corresponding ratios in the analyses, taking one-eleventh of the silica as unity, are

	I.	II.	III.	IV.	V.	VI.	VII.
SiO_2	11·00	11·00	11·00	11·00	11·00	11·00	11·00
Al_2O_3	1·95	1·89	1·99	2·04	1·97	1·99	1·97
Protoxides	5·30	4·99	4·74	4·65	4·79	4·81	4·72
H_2O	1·37	1·39	1·51	1·23	1·14	1·16	0·63

These ratios are not quite 11 : 2 : 5 : 1, the reason being perhaps on account of the incomplete separation of the aluminum and beryllium, that the water is in excess may result from a partial loss by ignition due to enclosures or something other than combined water. That water and alkalies are constant constituents of beryl may be further shown by the following water and alkali determinations on five beryls which are at my disposal. The alkalies were in all cases determined by a Smith's fusion on one-half gram each. The chlorides were weighed, without pretensions to exact quantitative work, and tested with the spectroscope. They will serve simply to give an idea of the quantity of alkalies.

	Water.	Weight of chlorides.
Green crystal, Portland, Conn.	2·44	0·0194 NaCl, LiCl.
Pale yellow, Haddam, Conn.	1·97	·0047 NaCl, LiCl.
Pale yellowish green, Delaware Co., Pa.	2·21	·0062 NaCl, LiCl.
Green, Acworth, N. H.	2·05	·0052 NaCl, LiCl, CsCl.
Green, Monroe, Conn.	1·65	·0064 NaCl, LiCl, CsCl.

The results of the investigation prove then, that alkalies are always present, undoubtedly replacing the beryllium; that water is also present and cannot be disregarded in the formula, and that the formula $Al_4Be_5H_2Si_{11}O_{34}$ is the one agreeing best with the analyses.

Alkalies have previously been noticed in beryl by M. B. Levy* who found 0·70 per cent Na_2O in material from Muso, New Granada, and by E. Bechi,† who found 0·88 per cent Cs_2O and 3·31 per cent BeO in material from Elba.

* Ann. Chim. Phys., III, 53, 5. † Jahrb. Min., 1872, 95.

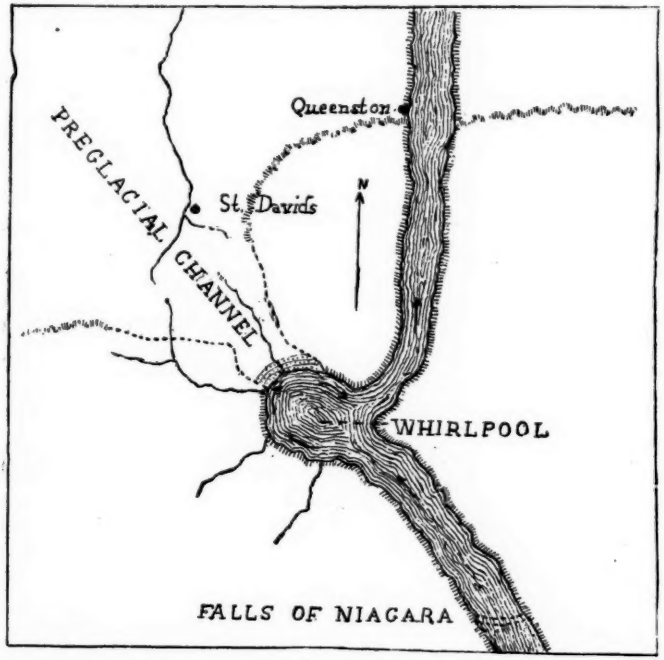
I publish these results, although incomplete in many respects, because the facts as far as made out are of interest and because I shall not be able to resume the investigation till the winter of 1884 and '85. I hope, however, to add to this a second paper which will serve to clear up some of the doubtful points. In closing, I take pleasure in expressing my thanks to Professor George J. Brush, for his kindness in providing me with most of the material for this investigation, and to Professor O. D. Allen and Mr. George F. Kunz, for the material which they furnished.

Sheffield Scientific School, March, 1884.

ART. V.—*The Niagara River and the Glacial Period;* by Professor G. F. WRIGHT.

HAVING recently made a study upon the ground of the Niagara gorge, I will give as briefly as possible such additional facts to those already well known as my glacial studies specially led me to observe. The accompanying plate (prepared to illustrate an article on the subject in the *Bibliotheca Sacra* for April, 1884) shows at a glance the situation. From the falls to Queenston the distance is about seven miles, and the gorge continuous, averaging about three hundred feet in depth and eight hundred feet in width, though in some places it is thirteen hundred feet wide. At Queenston the river emerges from the gorge and pursues its way to the lake through a low and level region. Following the rocky escarpment from Queenston to the west, it disappears after a distances of three miles, near St. David's, under a vast deposit of water-worn gravel and sand sloping gradually to the northwest. After passing two or three miles farther to the southwest, the rocky escarpment reappears. Thus we have here what would seem to be an indentation of the preglacial coast-line rather than the opening of a gorge formed by a preglacial river. This, which clearly is a water deposit of the Champlain period, continues for some distance, at least, on the high lands as a ridge overlying the till, like the lake ridges of Ohio. Upon going southeast from St. David's towards the whirlpool, one finds these accumulations of sand and gravel merging not far from the watershed in a deposit of true till—containing striated stones, and being without stratification. This continues to the whirlpool, and striated stones were found within the limits marked on the plate as Preglacial channel, where it faces the whirlpool, and twenty-five or thirty feet below the upper surface. The collection of debris, however, is such as to interfere with observations at a lower level.

A walk from the angle in the escarpment just below the whirlpool to the letter H in the word "Channel" discloses the following succession of phenomena: 1st. For a few rods the bare limestone rock; 2d. After a sudden rise of a few feet, we pass for about a hundred yards over deposits of sand and gravel which were doubtless made in the old bed of the river when the falls were below the whirlpool; 3d. We reach the old bank of the river, which consists of till, and rises fifteen or twenty feet. Till, bearing numerous granitic bowlders, continues for two or three miles of an unknown depth. At the letter H the sand deposits, before described, begin. The small stream



flowing through the preglacial channel into the whirlpool nowhere uncovers the rock; hence it may be inferred that there is a buried channel from the whirlpool to St. David's. Still, there is no direct proof of this, as, for a space of two miles, the surface of the country is unbroken and the till from twenty to thirty feet deep. The well to which Sir Charles Lyell indefinitely refers (See Travels in America [First Visit] vol. ii, p. 79) was probably somewhere in the broad opening on the St. David's side, from which little could be inferred. This buried channel where it

emerges from the whirlpool could not have been much over five hundred feet in width, since the first three streams entering into the whirlpool cut through the till to the rock, and descend in cataracts of varying heights; and the distance from the rocky escarpment disclosed by the third stream to the escarpment upon the north side of the whirlpool is not much more than five hundred feet.

That the supposed preglacial channel was not made by a stream comparable in size at all to the present Niagara is probable: *First*, from the shape of the whirlpool recess, which looks more like an enlargement of a gorge which would be naturally made by a united stream that had worn back its channel to a point where two or three branches came together. *Secondly*, the length of the gorge from St. David's,—about six miles,—even if it extended to near the present site of the falls, is entirely too short to represent the work done during preglacial ages by a stream of anything near the size of the Niagara. This follows upon comparison with the enormous amount of preglacial erosion that is everywhere manifest south of the glaciated area, where the preglacial channels have not been buried. Waterfalls may be said to be unknown south of the glaciated area. The trough of the Ohio River and its extension up the Allegheny—for a distance of fifteen hundred miles—has been formed by erosion, such as is going on at Niagara, and may be taken to represent in amount what would have been done by the Niagara River had it flowed in its present channel during preglacial ages. *Thirdly*, we know from direct evidence that the preglacial drainage of Lake Erie was two hundred feet below its present level. This is proved by Professor Newberry's discovery—made known several years ago—that the bottom of the preglacial bed of the Cuyahoga River, opening into the lake at Cleveland, is two hundred feet below its present level. Whether the theory of Professor Spencer (described in Second Geol. Report for Pennsylvania, Q4, p. 359 sq.) concerning the existence of a preglacial outlet from the mouth of Grand River to the head of Lake Ontario be correct or not, is independent of the conclusion that there must have been such an outlet somewhere. Whatever erosion, therefore, was done in preglacial times along the present course of the Niagara must have been accomplished by some small stream draining a limited area.

It seems to me probable that the Niagara River has itself worn the whole of the gorge from Queenston to the falls, with, perhaps, a very little help from preglacial erosion above the whirlpool; though this is a point difficult of absolute determination.

As to the rate of erosion, it now seems that that fixed upon by

Mr. Bakewell in this Journal (see January, 1857, pp. 87–93) was not far from correct; namely, about three feet a year, which would make the time required not over ten thousand or twelve thousand years. These rates of recession have been recently obtained by Dr. Pohlman by comparing the position of the horseshoe fall fixed by Professor Hall's survey of 1841 and the position as determined by the United States Survey in 1875. Dr. Pohlman's paper will soon be published in the Proceedings of the American Association. Mr. James T. Gardiner, of the present New York Survey, informs Professor A. Winchell (see World Life, p. 371) that this rate cannot be far from correct.

The rate of recession for Niagara falls corresponds with inferences drawn from the amount of post-glacial erosion which has taken place in the numerous small streams of Northern Ohio emptying into Lake Erie. For example, there is at Elyria, Ohio, a waterfall in Black River, a small stream about thirty miles in length. The gorge below the falls, which represents the work done by that stream since the Glacial period, is only about sixteen hundred feet in length; and this is about the length of numerous other gorges in Northern Ohio where small streams break over the Waverley sandstone into Lake Erie; and so everywhere the contrast between the amount of erosion accomplished by streams in corresponding strata in post-glacial time and that done in pre-glacial time, such as indicated in the statement just made concerning the Ohio, is perfectly astonishing.

Oberlin, Ohio, May 2.

ART. VI.—*Note on the Discovery of Primordial Fossils in the Town of Stuyvesant, Columbia County, N. Y.;* by S. W. FORD.

ON page 406 of Mather's Report on the Geology of the First District of the State of New York, published in 1843, attention is called to certain brecciated and conglomerate limestones occurring in the extreme northwestern portion of Columbia County; and on plate 23 (fig. 8) of the same work, a section is given to illustrate their stratigraphical relations. The rocks are treated of by the author in the chapter devoted to the consideration of the Birdseye and Black River Limestones; and although no fossils are cited from them in proof, the series is regarded as not improbably an inverted one, the older masses occupying the summit of the section. I have recently examined with some care the rocks referred to, and find Mather's section to be substantially correct, except that I do not find any limestone courses in his lower division (*a*).

The strata in question make a conspicuous feature in the

topography of the region. Commencing at Schodack Landing, in Rensselaer County, they may be traced southward, with slight interruptions, along the east shore of the Hudson River, for nearly three miles; and for a goodly portion of this distance they are finely displayed. In some instances they constitute bare, natural cliffs, more than a hundred feet in height. They may be studied to good advantage in a number of places, but one of the best points is in the old quarries a short distance north of a line running due eastward from Mr. Peter McCabe's ice-house. At this point I was enabled to obtain the following measured section, which will, I think, be found in the main correct. The strata are enumerated in ascending order, or, as they are met with in passing from the Hudson River Railroad track upward.

SECTION.

1.	Bluish-gray slate	80 feet.
2.	Dark blue, compact limestone, in regular courses, with slight shaly partings	13 "
3.	Reddish quartz rock	1 foot.
4.	Green calcareous slate	6 inches.
5.	Reddish quartz rock	9 "
6.	Green calcareous slate	10 feet.
7.	Even-bedded limestone becoming brecciated at top	5 "
8.	Bluish-gray slate, say	10 "
	Total thickness about	120 feet.

All of the above mentioned beds succeed one another conformably, and all belong, with but little doubt, to one and the same physical group. The fossils obtained from them prove that they belong to the Primordial zone, and to that division of it known as the Lower Potsdam. The paleontological evidence in detail is as follows:

From the limestone deposit near the top of the escarpment (No. 7 of the section) I have thus far obtained the following eleven species: *Palæophychus incipiens*, *Obolella crassa*, *Stenotheca rugosa*, *Hyolithes Americanus*, *H. impar*, *Hyolithellus micans*, *Microdiscus lobatus*, *M. speciosus*, *Conocoryphe trilineata*, *Olenellus asaphoides* and *Fordilla Troyensis* Barrande.

From the dark blue flinty limestones a short distance below (No. 2 of the section) I have obtained but a single species, the *Microdiscus speciosus*.

The slate deposit (No. 1) is likewise fossiliferous, but I have not yet found opportunity to minutely examine it. From a promising layer occurring within a short distance of its visible base, however, I have obtained a specimen which appears to me to be most likely a shell of the Pteropod species *Hyolithellus*

micans. Now, when we remember that all of the above species, omitting the *Palæophycus incipiens*, are among the commonest species occurring in the Troy Primordial beds; and when we further recall that, as a physical group, the rocks affording them are undistinguishable from those at Troy; it seems to me conclusive proof that the Columbia County beds are simply a southern prolongation of the Troy series. There is certainly no evidence that the slates below limestone deposit No. 2 are of the age of the Hudson River Group; nor is there any evidence, so far as I have been able to discover, that renders it necessary to appeal to an overturned and denuded fold, instead of a fault, to explain the geological structure of the region.

Additional Note.

Since the above was written, I have examined nearly all of the more southerly exposures of the conglomerate limestones mentioned by Mather, among others those of Great Neuten Hook, near Coxsackie, Merino Mountain, south of Hudson, and that in the neighborhood of Linlithgo in the town of Livingston, Columbia County; also the still more easterly locality which he cites, about four miles east of Rhinebeck, in Dutchess Co. Although my excursion was a somewhat hurried one, and my search for fossils at the several points visited was in the main unsuccessful, the impression made upon my mind by the facts observed, was yet strong that Mather was right in placing all of these rocks in the same great group or zone. The limestones east of Rhinebeck village are more altered than those of Troy and Stuyvesant, but otherwise perfectly resemble them; and moreover they contain traces of fossils, although I was unable to obtain any good specimens. Neverthless, I have scarcely a doubt that they will yet furnish well-characterized examples of the Lower Potsdam fauna. In the course of my studies, I examined nearly all of the exposures of rock along the Hudson River Railroad, and also, to some extent, those further inland beyond the bays and marshes (for the course of the great Appalachian break, though here for the most part a north-and-south one, is, in certain places, grandly undulated), from Schodack Landing to the first railroad tunnel, three miles south of Rhine Cliff station, at which point there is a splendid example of unconformability between the older and newer groups. The rock through which the tunnel passes is almost certainly the Hudson River slate, while the strata which wall against it are in all probability Primordial. The Lower Potsdam group in Canada, below Quebec, has a thickness of at least 2,000 feet, and its thickness is manifestly very great in Eastern New York. In consequence of the generally oblique direction of the folds of the region to the course of the fault referred to, cross-sections of some of the more easterly folds and ridges are constantly appearing in passing southward along the river, and excellent opportunities for their detailed study are thus presented.

Johnstown, N. Y., May 31st, 1884.

ART. VII.—*Notes on some apparently undescribed forms of fresh-water Infusoria;* by Dr. ALFRED C. STOKES.

IT is desirable but not always possible to ascertain the favorite position of an infusorian, whether near the surface of the water or near the bottom. Occasionally inferences can be made from the relative numbers captured at different depths, and it sometimes happens that a glance at the contents of the digestive vacuoles will indicate the infusorian's relation to depth, yet it quite as frequently happens that the food particles are so matted together, and the collection so compressed, that a correct diagnosis is not possible. Instances do occur, however, among the free-swimming types, when the food within the sarcode will show whether the animalcules prefer to grovel in the ooze or to float on the sunlit water. To this class belong the following hitherto undescribed forms, all of which were taken from the debris and sediment at the bottom of an aquarium kept without macroscopic animal life solely for the cultivation of the infusorial inhabitants, or collected from the ooze of shallow pools under the open sky.

The food of the new species of Loxodes, which I have named *Loxodes vorax*, and the creature's favorite position are easily ascertained. Although it does not disdain a monad when it comes convenient, yet its most favored diet is diatoms and small rhizopods. Of the former any of the freely floating, non-stipitate varieties seem acceptable, frustules being rarely absent from the body contents, siliceous valves one-third the infusorian's length often gorging it; in one or two instances its voracious appetite has led it to capture a frustule so nearly equal to itself in length that, when attempting to bend its elastic body as it seems to take pleasure in doing, one end of the long diatom has been forced up the pharyngeal passage and out of the oral aperture, and when curving in the opposite direction, the diatom has been so pressed against the cuticular surface that the latter has appeared on the point of rupture; if the creature had been spitted it could not have been more effectually stiffened. The most alluring of the rhizopods is the little *Trinema enchelys* Leidy. To the writer it has been a source of amusement as well as astonishment, to witness Loxodes apparently examine a diatom frustule or a rhizopod shell, never accepting the one if entirely free from endochrome, nor the latter if empty. I have seen it seize Trinema and make great efforts to force the shell through the pharynx, but when the morsel proved too large for the expansible passage, reject it, swim about the neighborhood for a few moments, return and repeat the attempt a second and a third time before finally abandoning it.

The Ehrenbergian species of Loxodes, *L. rostratum*, I have not seen, and, so far as I can learn, nothing has been recorded in reference to its food habits. The superficial resemblances between it and *Loxodes vorax*, are sufficient to point out the generic position of the latter if not the life haunts of the former. Their anatomical differences are, however, more conspicuous than their likenesses.

Loxodes vorax, n. sp. (fig. 1) has the elongated and flattened body characteristic of the genus, the dorsal surface being somewhat convex, the ventral flattened and finely striated longitudinally, these delicate furrows bearing the vibratile cilia. The generic diagnosis describes the dorsal region as perfectly smooth, but the present species, under a high degree of amplification has that surface roughened by very minute, irregularly disposed elevations. In other respects it differs externally from the hitherto single known species in its smaller size, less proportional width, the evenly rounded, somewhat narrowed and attenuated posterior extremity, which is not curved but lies in the plane of the body, in the absence of any angular margin, in the greater breadth of the adoral groove, and in the different arrangement of the dorso-lateral setæ. The latter, in *L. rostratum* Ehr. appear to project horizontally from both sides of the body. With *L. vorax* the sub-horizontal arrangement obtains on the left hand margin where they are usually conspicuous, but beginning at the posterior extremity they leave the right-hand border by a considerable interval, projecting more and more obliquely upward until they stand almost erect, and become visible only on careful focussing.

The adoral groove is much wider than in the type. The usual corneous membrane is borne within it, and is continued into the body to form the tubular pharynx. Its color changes to a chestnut-brown with age, as is the case with the loricæ of certain of the Vaginicolinæ. For this reason the inference is that the chemical composition of the two tissues is identical. Slight experimentation, however, renders this somewhat doubtful. It is well known that the loricæ of Vaginicola and of Pyxicola will for a long time resist the action of caustic potassa in solution. The pharynx and adoral membranous lining of *Loxodes vorax* are rapidly and entirely dissolved by it. So slightly corneous or chitinous is this lining that even a drop of picro-carmine staining fluid destroys it. The whole adoral groove is remarkably flexible and elastic, as indeed is the entire body. The broad furrow can be dilated until it is hood-like or expanded until it is almost a flat surface. Together with the anterior beak it can be bent until it is in contact with the center of the ventral region, or nearer the oral aperture proper. The last is the position when a monad or other equally small and

active food particle is to be engulfed. The beak-like front is flexed, the groove-bearing part dilated and, with the aid of the cilia, formed into a trap from which usually the only escape is down the pharynx. The pharynx itself is short and conical, lacking the curvature so conspicuous in the same part of *L. rostratum* Ehr.

The sarcode is not noticeably vacuolar as it is in the Ehrenbergian species. A few scattered lacunæ at times appear posteriorly, but the remarkable trabecular aspect common with *L. rostratum* I have not observed. Neither has a contractile vesicle been positively distinguished; a spherical vacuole is quite constantly present in the posterior body half, but it has not been seen to pulsate.

The nuclei of the type species are described as numerous, scattered throughout the body, and connected together by a funiculus, to which nucleoli are often laterally attached. Such a complicated arrangement I have been unable to detect in *L. vorax*, even after the use of reagents. Here the nucleus seems to be composed of two, separated, nucleolated, spherical nodules, without a connecting funiculus.

The only method of reproduction observed is by obliquely transverse fission. In one instance the partially separated creatures, not content to await the result of the slow action then taking place, deliberately pulled themselves asunder. The body is at times able to adhere to the glass slide or other support, and it here took advantage of that power, clinging to a mass of dirt while the separating portion forcibly pulled a long sarcode thread from the parent's body, and continued its efforts until the thread snapped. The following description probably contains the essential specific characters.

Loxodes vorax, n. sp.—Body very flexible and elastic, elongate, flattened, from three and one-half to four times as long as broad, anteriorly somewhat curved to the left-hand and ending in a beak-like apex, posteriorly evenly rounded, somewhat tapering and attenuated; adoral groove wide; pharynx tubular, conical and straight; cilia confined to the ventral surface and distributed throughout the fine longitudinal striations, those at the posterior extremity being somewhat more conspicuous, a row of slightly larger cilia bordering the adoral groove; dorsal surface, under high amplification minutely granulate; marginal hispid setæ projecting sub-horizontally from the left-hand margin, somewhat removed from the right-hand dorso-lateral border and becoming more perpendicular as they approach the anterior extremity; parenchyma pale brownish-yellow, seldom conspicuously vacuolar; contractile vesicle (?) single, in the posterior body-half; nucleus double, sub-central, each part spherical and nucleolated, a funiculus not apparent; numerous

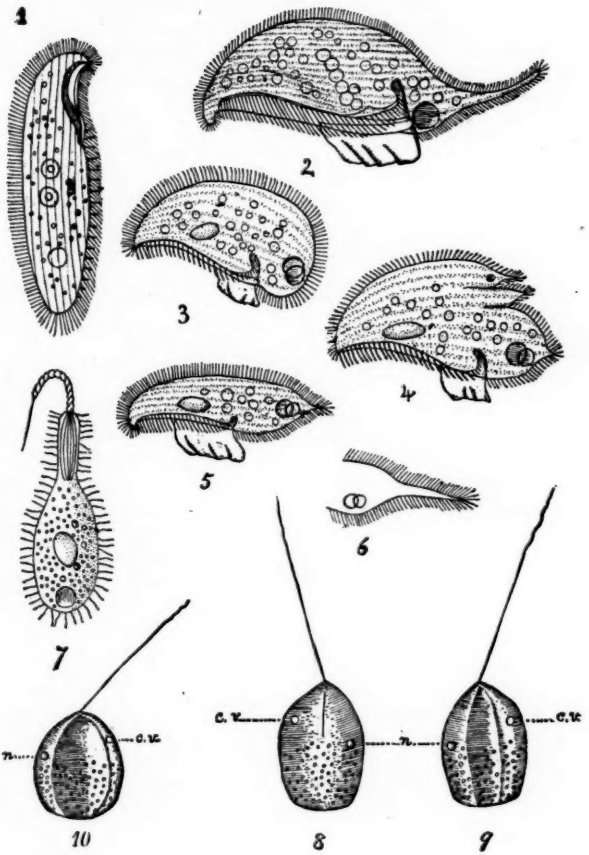


Fig. 1. *Loxodes vorax*, sp. nov. × 300.
Fig. 2. *Apgaria undulans*, gen. et sp. nov. × 380.
Fig. 3. *Apgaria ovata*, sp. nov. × 200. The tail-like prolongation retracted.
Fig. 4. *Apgaria ovata* undergoing longitudinal reproductive fission.
Fig. 5. *Apgaria elongata*, sp. nov. Tail-like prolongation partially retracted. × 275.
Fig. 6. The same with extended tail in outline.
Fig. 7. *Ileonema dispar*, gen. et sp. nov. × 220.
Fig. 8. *Solenotus apocamptus*, gen. et sp. nov. × 1750. Ventral aspect, showing short flagellum.
Fig. 9. *Solenotus apocamptus*, sp. nov. × 1750. Dorsal aspect, showing longitudinal furrow.
Fig. 10. *Solenotus orbicularis*, sp. nov. × 1320. Dorsal aspect.

small refringent corpuscles scattered throughout the body; anal aperture dorsally located, at a short distance in advance of the posterior extremity. Length of body $\frac{1}{180}$ to $\frac{1}{200}$ inch. Habitat—Standing water, chiefly among the decaying debris on the bottom.

Another infusorian, but a member of the *Ciliata-Heterotricha* whose appearance is attractive and its motions graceful, I have taken in small numbers from the debris at the bottom of the aquarium referred to. Its movements are not rapid, consisting chiefly of a steady progression by swimming usually on the right-hand side, or by rotation upon its longitudinal axis. There is, so far as I am aware, no infusorial genus capable of receiving it; I therefore take pleasure in naming it in honor of my learned friend, Mr. Austin C. Apgar, Professor of Zoology in the New Jersey State Normal School.

Apgaria, gen. nov.—Body irregularly ovate, more or less flattened or lamellate, entirely ciliate, soft, flexible, transparent and somewhat changeable in form; the anterior extremity slightly curved toward the left-hand border, and terminating in a more or less beak-like apex; the posterior extremity with a retractile tail-like prolongation; the right-hand body-margin convex, the left-hand border somewhat sigmoid and bearing an elongate-ovate groove or depression extending backward and obliquely inward, the oral aperture being at its posterior widest and deepest part; pharynx tubular, anteriorly curved, expansile and ciliated; the left-hand edge of the peristome field bearing a single row of long vibratile adoral cilia continued around the mouth and into the pharynx, the basal portion of the right-hand margin occupied by a conspicuous, lamellate, undulating membrane; cuticular cilia fine, clothing the longitudinal surface furrows; nucleus moniliform or rounded, subcentrally located; contractile vesicle single or double, posteriorly placed; anal aperture posterior, near the pulsating vacuole.

Apgaria undulans, sp. nov.—(fig. 2).—Body leaf-like and lamellate, longitudinally furrowed, the length twice to two and one-half times the breadth, transparent and irregularly vacuolar, a large, conspicuous vacuole usually beside the contractile vesicle; anterior extremity terminating in a rounded, beak-like projection directed toward the left-hand border; the right-hand margin usually evenly convex and continued through a sinistrally directed concavity into the tail-like prolongation, the whole border thus presenting an elongated S-shaped outline; the left-hand margin somewhat sigmoid and continued into the tail as a sinistrally directed convexity; the posterior tail-like prolongation retractile to a short, conical projection, but when extended, curved toward the right-hand border and

forming about one-third of the entire length of the body; cuticular cilia long and fine; peristome field a long channel occupying somewhat less than the anterior two-thirds of the left-hand border, taking its origin at a short distance posteriorly to the beak-like apex, the margin bearing the adoral cilia projecting laterally, its outline sigmoid, its free edge conspicuously thickened; adoral cilia long, continued around the mouth and into the narrow, ciliated, anteriorly curved pharynx; the undulating membrane large, delicate and very flexible, its base of attachment extending obliquely within the adoral channel and about the posterior margin of the oral aperture; nucleus conspicuous, moniliform, more or less sigmoid, obliquely and subcentrally placed; contractile vesicle single, spherical, posteriorly located near the left-hand border at the base of the tail-like prolongation. Length of body $\frac{1}{200}$ inch. Habitat—Standing water, among the residual detritus at the bottom.

This noble infusorian is represented in figure 2, magnified about 380 diameters. Its habitat seems to be restricted to that just mentioned, as I have been unable, even after careful search, to take it elsewhere, and from thence only after the sediment has been disturbed and the animalcule captured before it could again bury itself. It is essentially a mud-loving form, and seems rare. I have taken but six individuals after prolonged searching. The nucleus is commonly composed of from four to seven nodules, including the single one usually laterally attached.

The numerous scattered vacuoles are generally circular in optical outline; they frequently collect together near the median line and gradually disappear. The larger, more conspicuous one near the pulsating vesicle is commonly of irregular outline and quite persistent, seldom more than slightly changing its form.

Apgaria ovata, sp. nov. (fig. 3).—Body irregularly ovate, length once and one-half to twice the breadth, the posterior region somewhat inflated, the anterior flattened, the beak-like apex short, acute and inconspicuous or obsolete; the posterior extremity usually rounded and the short, acute, conical tail-like prolongation entirely retracted; peristome field occupying the anterior three-fourths of the left-hand border, its margins sigmoid, not projecting laterally; the adoral ciliary fringe originating at the anterior apex; undulating membrane narrow, attached to the basal third of the right-hand peristome border, not obliquely inserted and not entirely surrounding the mouth posteriorly; nucleus ovate, situated in the anterior body-half near the left-hand border; contractile vesicles two, posteriorly placed, pulsating alternately; anal aperture large, in close proximity to the contractile vacuoles. Length of body $\frac{1}{300}$

inch. Habitat—The surface of submerged twigs and decaying leaves at the bottom of shallow pools.

The tail of this form is the shortest of any yet observed, and an individual in any other than the retracted state represented in figure 3 is uncommon, although the infusoria are not rare. It is also the least changeable in form, a slight elongation of the body being about the extent of its alteration. When in motion, like the others it rotates on its longitudinal axis, but it is not rapid. The animalcule frequently remains motionless in the field of the objective for half an hour at a time, either feeding or awaiting the result of its ciliary currents. Its appetite is voracious. Spores, unicellular algæ, small infusoria, diatoms, almost any minute living thing seeming acceptable. The undulating membrane is active in the feeding process, waving and bending across the oral fossa and forming the roof of a food-trap which, if occasion demands, descends and thrusts the morsel into the mouth. The anal aperture is remarkably large and, at times, is temporarily conspicuous as a postero-terminal depression with a puckered margin. It frequently opens in connection with the pulsating vacuoles, a great part of the creature's posterior extremity then appearing to give way, beaded threads of sarcode sometimes streaming into the water, and rapidly receding. The pulsating vacuoles after contraction are followed by several internal well-marked sarcode threads or folds, which gradually fade away to reappear after the next pulsation. Their function I have not even conjectured; neither have I observed them in any other infusorian. There is one condition, however, in which the tail is well exhibited, and that is during the reproductive process. This takes place by longitudinal fission, one individual becoming three by the almost simultaneous separation of two zooids from the body of the parent, as in figure 4. After the process the tail-like projections are withdrawn and the young differ from the mature forms in size only. I am not aware that a similar triple longitudinal fission has been previously observed.

Apgaria elongata, sp. nov.—Body elongate-ovate, flattened, three to four times as long as broad; beak-like apex distinct; posterior portion continued as a centrally directed, acute, conical tail-like prolongation, which, when extended is about one-fifth the entire length of the body; peristome field occupying the anterior one-half of the left-hand border, its margins scarcely sigmoid and not projecting laterally; the adoral ciliary fringe originating at a short distance posteriorly to the beak; undulating membrane wide, attached to the basal one-half of the right-hand margin of the peristome channel, its insertion not conspicuously oblique and not surrounding the mouth; pharynx short, ciliated; nucleus elongate-ovate, in the anterior

body-half near the left-hand border; contractile vesicles two, situated at the base of the tail-like projection, and contracting alternately. Length of body $\frac{1}{300}$ to $\frac{1}{350}$ inch. Habitat—The surface of water-soaked twigs and decaying leaves at the bottom of shallow pools.

Figure 5 represents this infusorian with the tail partially withdrawn, as most commonly seen; figure 6 an outline of the same part extended. Its movements are the most rapid, and its changes of form the greatest of any member of the genus yet met with. The body is very flexible, and is frequently twisted temporarily.

The systematic position of the genus is probably near that of Blepharisma.

Another animalcule collected in some abundance in one of the first gatherings of early spring seems to have no recognizable generic resting-place. It may be characterized as follows:

Ileonema, gen. nov. (Greek *eileo*, to twist; *nema*, a thread.)—Body flask-shaped, depressed, elastic, entirely ciliate; flagellum single, inserted at the narrow anterior extremity, flexible but not vibratile, the basal half large, thick and apparently twisted, the distal half fine, thread-like; oral aperture terminal, perforating the apex of the neck-like portion; pharynx distinct; nucleus sub-spherical or broadly ovoid, sub-central; contractile vesicle single, posterior placed; anal aperture postero-terminal.

Ileonema dispar, sp. nov. (fig. 7.)—Body transparent, granular, flexible, flask-shaped, longitudinally striate, the length about three times the breadth, contracting to a short ovoid form or extending until clavate; the ventral surface flattened, the dorsal convex and bearing a single longitudinally disposed row of short hair-like perpendicular setæ; cilia long and fine, thinly clothing the surface; entire flagellum one-half the length of the body, the basal half thick, obliquely grooved and presenting a twisted or cord-like appearance, slightly tapering yet suddenly constricted at the beginning of the finely filamentous distal one-half; oral aperture at the base of the flagellum; pharynx elongate-fusiform, longitudinally plicate, apparently composed of delicate elastic, rod-like elements; nucleus ovoid, sub-central; contractile vesicles two, postero-terminal, close to the anal aperture. Length of body $\frac{1}{200}$ inch. Habitat—Among algæ and decaying leaves at the bottom of shallow pools.

This bottle-shaped infusorian (fig. 7) was taken from among those delicate algæ which grow so abundantly in all quiet waters, and seem to cling like soft green clouds to leaves of grass and fragments of sticks and twigs in the shallow wayside pools of early spring. Its movements are evenly swimming

without rotation and without much hurry. Its changes of form are, however, quite constant as it rests among the algal threads and lengthens the entire body into a club-shaped creature searching for food, or contracts into an egg-shape with a short, narrow neck. Normally its contour closely resembles that of *Tracheophyllum apiculatum* (Perty), C. & L. If, from the latter, the acutely conical anterior apex be removed, and the flagellum of *Ileonema* be added, the result would be a species of the genus now under notice, the likeness between the contracted forms being also striking.

The fine long cilia are not abundant. They vibrate irregularly and, to a certain extent, independently of each other.

The distal one-half of the flagellum is extremely fine, and is often absent, as, indeed is the entire appendage of individuals kept long in confinement. When the filamentous portion has been lost, the cord like half frequently ends in a bulbous enlargement, and even this the animalcule often loses, apparently without injurious results. This bulb seems to be sticky; it at least easily attaches itself to foreign bodies, and I have witnessed its owner, after several attempts, forcibly tear itself loose and lose the bulb. The whole flagellum is generally carried trailing and curved to one side, occasionally being extended and used apparently as a feeler.

If this organism is a member of Claparède and Lachmann's Cilio-Flagellata, then the diagnosis of that order must be somewhat modified. As it now stands the description states that the flagellum is the chief organ of locomotion. With *Ileonema dispar* that appendage has no active connection with the animalcule's movements. Its position in the latest scheme of classification seems to be so close to the indistinctly defined line of separation between the Flagellata-Eustomata and the Cilio-Flagellata, that it may be considered a link intimately connecting the two orders. Only a slight exercise of the observer's imagination is needed to put into vibration the filiform distal portion of the non-flexible, non-vibratile-flagellum, and to more densely clothe the cuticular surface with shorter, more uniformly moving cilia, in order to produce a typical member of the Cilio-Flagellata. When the flagellum has been lost, the infusorian possesses no character to distinguish it from the Holotricha, and if first met with in this condition any observer would classify it in that order. As it is, it makes the line of demarcation between these orders still more obscure.

I was at first disposed to consider the pharynx a membranous tube whose walls are thrown into longitudinal folds, but such interpretation was precluded by further observation. The passage is very dilatable, and the infusorian has the habit of widely expanding the posterior or internal extremity, as the body

assumes the ovate form, when folds would become extinct and rods or fibrillæ more conspicuous, which is in fact the case. That an elastic membrane connects the rod-like constituents of the passage, I have not been able to determine. My impression, however, is that none exists, the pharynx being merely an elongated cage-like structure open at each end, its delicate bars attached only around the oral aperture.

The following minute creatures are also apparently undescribed. They are deliberate, but eccentric in their movements, with the additional eccentricity of appearing to float back downward, having in that position the convex surface which an observer would at first glance decide to be the dorsal. That it is in reality the ventral aspect is proven, it would seem, by the fact that the short, trailing flagellum not only takes its origin from a point on that surface, but is habitually held beneath the convexity. It is scarcely possible that a non-vibratile flagellum could be of much service as a drag or as a pivot on which to turn, as this infusorian turns, if carried above the dorsum. Yet the animal frequently moves with this convex part directed upward, although this is the less common position. The long flagellum is entirely flexible, but usually only the distal extremity is vibratile. It is commonly held directed stiffly and obliquely toward one side as the animalcule floats with either surface downward, as shown in the figures. In fig. 8, is delineated the ventral aspect to exhibit the comparative length, origin, and usual position of the short flagellum.

If both the superior and inferior surfaces were equally convex, the creature would scarcely have formed so interesting a study, but the former, or dorsal aspect bears a subcentral, longitudinal channel or depression extending from the apex to the posterior extremity, thus giving the infusorian, when seen "end on," or in transverse optical section, a concavo-convex outline, somewhat like that of a longitudinal slice of a bean. This grooved surface is represented in fig. 9.

When moving through the water, it advances in a direct course steadily and not rapidly for a few moments, when it quickly and abruptly turns aside at an acute angle, the long flagellum then being thrown into indescribable curves and flexures, but in the general direction of the route to be taken.

No distinct oral aperture is visible. On several occasions numerous minute green particles, presumably of food, have been noticed within the endoplasm.

In its generic position it approaches nearest to Stein's *Colponema*, but is refused admission to that genus by the absence of the anterior curvature, by the apical origin of the trailing flagellum, and by the presence of a dorsal instead of a ventral groove. If the channel-bearing surface should be assumed to

be the ventral, Stein's genus would still be unable to receive the infusorian, since the short flagellum would then take its origin from the dorsal aspect, whereas in *Colponema*, one of these lash-like appendages arises from near the center of the ventral groove. Consequently, although a minute atom of vitality, it seems to demand recognition as the type of a new genus, of which the following may be taken as the diagnosis.

Solenotus (Greek *solen*, a channel; *notos*, the back), gen. nov.—Infusoria free-swimming, not changeable in shape, ovate, the anterior extremity slightly pointed but not curved to either side, the ventral surface convex, the dorsal concave, with a subcentral, longitudinal groove or channel; flagella two, diverse in length, one vibratile, the other trailing, both taking their origin anteriorly, the shorter from the smoothly convex aspect, not from the groove; anal aperture posteroterminal.

S. apocamptus (Greek *apokampto*, to turn aside), sp. nov.—Body depressed ovate, the length about one and one-third times the width; the anterior body half somewhat flattened, the anterior extremity with rounded borders but tapering to an acute, slightly projecting apex; the posterior body half narrowing, the extremity convex but somewhat truncate; ventral aspect smoothly convex; dorsal groove narrowest at its anterior origin, widening and thence continuing evenly to its posterior termination; flagella diverse in length and thickness, the longer and larger, once to one-half times as long as the body, inserted at the apex, and commonly held stiffly and obliquely in advance, the distal end alone vibrating; the shorter trailing, about one-third the length of the body, slender, arising from a point at a little distance from the anterior apex of the convex or dorsal surface; endoplasm granular especially posteriorly; contractile vesicle single, small, located anteriorly near the right-hand border; nucleus obscure, apparently placed subcentrally near the left-hand margin. Length of the body $\frac{1}{2500}$ to $\frac{1}{3750}$ inch. Habitat—Standing water with Myriophyllum.

Solenotus orbicularis, sp. nov.—Body suborbicular, the anterior apex obtuse, the posterior extremity rounded not truncate, the posterior one-half of the left-hand border angular; dorsal groove broad and shallow; ventral surface evenly convex; flagella, nucleus and contractile vesicle similar to those of the preceding species. Length of the body $\frac{1}{2200}$ with $\frac{1}{2500}$ inch. Habitat—Near the bottom of the shallow water of small pools.

This infusorian (fig. 10) differs from that described as *Solenotus apocamptus*, chiefly in its contour, its shorter dorso-ventral or vertical diameter, and in the shallowness and greater

comparative width of the dorsal depression. Its movements are similar to those of *S. apocamptus*, the long flagellum being held somewhat more obliquely than with that species. The body is frequently elevated during its progression so that the apex seems to be held in contact with the slide, a position not observed with *S. apocamptus*. The anterior body half is transparent; colorless corpuscles and green food-particles collected posteriorly render that part semi-opaque.

Trenton, N. J.

ART. VIII.—*The Causes of Variation;* by ROMYN HITCHCOCK.

THE recent studies of Dr. W. B. Carpenter upon *Orbitolites*, which were noticed in the April number of this Journal, are of special interest owing to the remarkable manner in which the stages of variation and development have been traced. The monograph by Dr. Carpenter, published in the Reports of the 'Challenger' Expedition, was the subject of some remarks recently made by the writer before the Biological Society of Washington, in which an effort was made to explain how such a simple sarcode organism as the animal *Orbitolites* had been led to produce a shell of complex form. Dr. Carpenter regards it as the expression of a not understood "progressive tendency along a definite line towards a higher specialized type of structure in the calcareous fabric." This, however, is merely a statement of the facts observed, and in nowise assists in their explanation. Elsewhere it may be gathered from the author's words that he regards the complex shell as significant of a "*plan* so definite and obvious, as to exclude the notion of '*casual*' or '*aimless*' variation."

The facts seem capable of a somewhat different interpretation, which seems more in accord with our present knowledge of simple organisms, and quite sustaining the views of Darwin that "plan," in the sense used by Dr. Carpenter, should be, superfluous. For if there be an inherent tendency to variation among these organisms, as Dr. Carpenter seems to believe, how do we explain the persistence of the original orbitoline type *O. tenuissima?* Biologists seek to discover the causes of variations which they observe, but it seems not less important that the persistence of types should also be explained. *O. tenuissima* is a very ancient species, and surely any inherent tendency to change would have manifested itself during the long period of its existence, even under unfavorable conditions.

The observations I have to offer may be said to relate entirely to change of environment, but their tendency is to

demonstrate that the changes observed in the shells of this family are not due to any inherent tendency resulting in a definite plan, but that they are due to causes easily understood.

It is far from my intention to deny a definite plan of growth to these organisms. But plan of growth does not imply that there have been causes acting within the organism—special tendencies of the protoplasm toward higher structure. It seems to be such an assumption that has led Dr. Carpenter to speak of a "not understood" progressive tendency, etc. In my opinion the causes of such progression as can be observed are easily understood; and the plan of growth becomes a natural consequence of these causes, which are purely physiological, and independent of any supposed tendency to variation. While Dr. Carpenter, on the one hand, seems to regard variation as due to an inherent tendency of the protoplasmic body, the writer, on the other hand, attributes it entirely to the more or less favorable conditions of life of the different species. Moreover, I am quite unable to understand how any inherent tendency to variation impressed upon the sarcode could fail to find expression in some differentiation of the sarcode, which in the cases in question has not been observed.

The same view seems to be held by O. Schmidt who, in his "Grundzüge einer Spongien-Fauna des Atlantischen Gebietes," alludes to Dr. Carpenter's previous studies, and compares the changes observed in the sponges and foraminifera. He says the changes in the latter are found in the general habit of the form and the variable grouping of the chamber-systems, while among the sponges the variation is in the microscopic detail. "One may speak of the microscopic form of foraminifera but not of microscopic elements."

The complexity of the shell is merely in the multiplicity of chambers and the manner of their intercommunication. The process of growth, even in the complex *O. complanata*, is in all respects identical with that in other species, and in no essential feature differs from that of *Peneroplis*. What Dr. Carpenter designates as a "higher specialized type of structure" does not represent an advanced degree of specialization in any part; nor can we discover any advantage to the organism arising therefrom. It is true there is an advance in complexity, but unless accompanying this there is an evolution in function, or unless it results from some effort of adaptation which confers some benefit upon the organism, it seems not proper to regard complexity of shell-structure as a proof of biological advancement.

Seeking for an explanation of the cause of the increased complexity of shell-structure, so beautifully illustrated in the milioline family, the writer was led to the conclusion that it is

entirely due to the favorable conditions of life and the abundance of food available. It is true, as already said, this may be regarded as a mere statement of the influence of environment causing variation, but a careful consideration of the subject will show that there is a broad distinction between environment as a cause of variation, and adaptation to environment; for in this case we are unable to perceive any benefit to the organisms arising from their adaptation to changed conditions.

If it be said we can seldom discover the benefits supposed to be derived from adaptation, it may be answered that it is usually possible to infer how the changes observed may prove beneficial. In the case under consideration, however, an examination of the changes that have taken place does not indicate any possible benefit to the organism. The multiplication of chamberlets necessitates very intimate intercommunication for the transference of food and the continuation of the processes of life. The organism is not thereby better adapted to its surroundings, but is made more dependent for its existence upon the continuance of the favorable conditions under which it has developed. The advance in complexity—the multiplication of chamberlets—would only be possible under the most favorable conditions, for all the nutriment received by the interior segments must be collected by the sarcode at the margin of the shell, and the necessary food could only be obtained where the supply was abundant. It may be conceived that if *O. complanata* were placed in situations less favorable as regards food it would die of starvation owing to the quantity of inner sarcode requiring nourishment, while *O. tenuissima* needs only more favorable conditions as regards food, and perhaps temperature, to become as highly complex in structure as the last-mentioned species. As a further proof of the influence of environment leading to changes which cannot be regarded as special adaptations, in the usual meaning of the word, the forms of *O. complanata* found on Fiji reef are especially characterized by thick, plicated margins, as though growth proceeded with too great rapidity to produce symmetrical disks, and these forms are associated with the largest representatives of the species.

The distinction above referred to seems an important one, which, if it has already been recognized, has not been prominently brought forward in the writings with which I am familiar. Before the Biological Society the subject was briefly considered in the following words:

"Regarding the subject from this point of view we are led to examine more closely the relations between the spiral and the cyclical methods of growth. Their intimate relation is only noticeable when we observe how one has been derived from the

other. When the spiral growth of *Orbiculina* produces a complete circular disk, further spiral growth becomes impossible, and if we concede that the extrusion of the sarcode to form successive chamberlets is due to nutrition and growth, the cyclical plan then becomes a necessity. In this way it may be supposed cyclical growth originated, purely a result of nutrition—not by adaptation to environment, but as a result of it; not because such growth is or ever was better adapted to the conditions of life.

"We find here a steady course of variation a result of physiological processes, independent of those external causes to which we are accustomed to attribute such changes. These variations, as successively produced, have been perpetuated through inheritance, until the plan of growth has, in some species, totally changed. Herein, therefore, we may find an indication of how the plan of growth originated, and a suggestion that the inscrutable laws which govern the progress of evolution may each have beginnings equally simple, and not beyond the range of human insight to discover. Evolution in this case seems not to be a result of a definite plan of growth, but the plan of growth is the result of physiological processes. However great and important the influences of environment and selection may have been in the production of genera and species, perhaps the attractiveness of the idea, and the ease with which it enables us to dimly understand many biogenetic problems, permits us to lose sight of other influences more obscure but of equal importance in the history of life."

This view of the subject seems to derive still further support from the geographical and bathymetrical distribution of the species. Without entering into a lengthy discussion of this part of the subject, it may be said that as a rule the more complex species are found in the warmer waters, under conditions most favorable to the activity of nutritive processes. As an example, the very large specimens of *O. complanata* from Fiji reef may be taken. On the other hand, the ancestral form *O. tenuissima* still inhabits the colder and deeper waters, retaining the simple characters of its earliest known condition.

National Museum.

ART. IX.—*Crustacea of the Albatross Dredgings in* 1883; by SIDNEY I. SMITH.

VERY little has yet been published in regard to the zoological results of the deep sea explorations carried on during the summer of 1883, by the United States Fish Commission, although the dredgings were among the most important yet made. Some of the remarkable forms of fishes discovered have been described by Drs. Gill and Ryder, but the writer's report on the decapod crustacea (80 pages of text with 10 plates), recently put in type for the Fish Commission Report for 1882, is the first detailed report on the zoological collection made by the Albatross, and affords an opportunity for a brief review of the results of the study of the higher crustacea, which is here published by permission of the Commissioner of Fish and Fisheries.

The dredgings of the Albatross extended from off Cape Hatteras to the region of George's Banks. The number of dredging stations was 116, of which 30 were in less than 100 fathoms, 35 between 100 and 500 fathoms, 19 between 500 and 1000 fathoms, 27 between 1000 and 2000 fathoms, and 5 below 2000 fathoms. The whole number of species of Decapoda determined from these stations is 72, but of these at least 15 are true shallow-water species. Of the remaining 57 species, 40 were taken below 500 fathoms, 29 below 1000 fathoms, 13 below 2000 fathoms, and 6 at a single haul in 2949 fathoms. Of the 29 species taken below 1000 fathoms, 21 are Caridea or true shrimp, and the 8 higher species distributed as follows: 2 Eryontidæ, 3 Galatheidæ, 1 Paguroid, 1 Lithodes, and 1 Brachyuran belonging to the Dorippidæ. It is interesting to compare these results with the lists of the fauna of the North Atlantic below 1000 fathoms, given by the Rev. Dr. Norman in the presidential address to the Tyneside Naturalists' Field Club, published last year. In Dr. Norman's lists only 12 species of Decapoda are recorded, none of them from as great a depth as 2000 fathoms, and of these 12 species, 7 were known only from the Blake dredgings of 1880.

The following are some of the more interesting new forms: a new genus of Brachyura allied to *Ethusa*, 1496 to 1735 fathoms; an Anomuran belonging to A. Milne-Edwards' new genus *Galacantha*, 1479 fathoms; two species of *Pentacheles* (a genus of Eryontidæ allied to *Willemœsia*), between 843 and 1917 fathoms; a stout Palæmonid (*Notostomus*), six inches long and intense dark crimson in color, 1309 to 1555 fathoms; a gigantic *Pasiphaë*, eight and one-half inches long, 1342 fath-

oms; three species of a remarkable new genus allied to *Pasiphaë*, and also to *Hymenodora* and some other genera of Palæmonidæ, which shows that *Pasphaë* is closely allied to the Palæmonidæ; a large Penæid, a foot in length, referred to the little known genus *Aristeus;* and a large *Sergestes* three inches in length.

The great size of some of these new species of shrimp is remarkable, but is far exceeded by two of the previously described crabs. *Geryon quinquedens*, from 105 to 588 fathoms, is one of the largest Brachyurans known, the carapax in some specimens being five inches long and six broad, while one specimen of the great spiny *Lithodes Agassizii* measures seven inches in length and six in breadth of carapax, and the outstretched legs over three feet in extent.

Among the Schizopoda there are two large species of *Gnathophausa*, one over four inches in length, and a *Lophogaster*, all from below 2000 fathoms. One of the most interesting Schizopods is a small *Thysanoessa* (a genus of Euphausidæ) from 398 to 1067 fathoms, of which one female was found carrying eggs. The eggs are carried in an elongated and flattened mass beneath the cephalothorax, are apparently held together by some glutinous secretion, and are attached principally to the third pair of peræopods (antepenultimate cephalothoracic appendages). This apparently confirms Bell's statement in regard to the egg-carrying of *Thysanopoda Couchii*, which is, as far as I know, the only published observation of egg-carrying in any of the Euphausidæ.

The Amphipoda from deep water are comparatively few in number and have not yet been carefully examined, but among them is one specimen of the gigantic *Eurythenes gryllus* Boeck (*Lysianassa Magellanica* Milne-Edwards), probably the largest of all known Amphipoda. This specimen, which is over four and a half inches long, and very stout in proportion, was taken in 1917 fathoms, north lat. 37° 56′ 20″, west long. 70° 57′ 30″. The few previously known specimens came from Cape Horn, Greenland, and Finmark, and have apparently all been taken from the stomachs of fishes. This species and its occurrence in the extreme arctic and antarctic seas, has been much discussed and is the subject of a long memoir by Lilljeborg, but the apparently anomalous distribution is explained by its discovery in deep water off our middle Atlantic coast.

The great differences in depth through which some of the species range is worthy of notice, several species ranging more than 2000 fathoms, as shown in the list, given further on, of species taken below 2000 fathoms. I have not yet noticed distinct varietal differences due to depth in any species, though there is often a very marked change in the associating species.

A very remarkable case is that of *Parapagurus pilosimanus*, which was taken at fifteen stations and in 250 to 640 fathoms by the Fish Hawk and Blake in 1880–'81–'82, and in great abundance at one station, in 319 fathoms, where nearly four hundred large specimens were taken at once. All these earlier specimens were inhabiting carcinœcia of *Epizoanthus paguriphilus*. In the dredgings last summer the *Parapagurus* was taken at seven stations ranging in depth from 1731 to 2221 fathoms, but none of the specimens were associated with the same species of *Epizoanthus*, some being in a very different species of *Epizoanthus*, others in naked gastropod shells, and still others in an actinian polyp.

A striking characteristic of the deep-sea crustacea is their red or reddish color. A few species are apparently nearly colorless, but the great majority are some shade of red or orange, and I have seen no evidence of any other bright color. A few species from between 100 and 300 fathoms are conspicuously marked with scarlet or vermilion, but such bright markings were not noticed in any species from below 1000 fathoms. Below this depth, orange red of varying intensity is apparently the most common color, although in several species, very notably in the *Notostomus* already referred to, the color was an exceedingly intense dark crimson.

The eyes of these abyssal species are even more remarkable than their colors, as the following list of the Decapoda and larger Schizopoda taken below 2000 fathoms by the Albatross, with the notes which follow, will show:

1.	Parapagurus pilosimanus	1731 to 2221 fathoms.
2.	Pontophilus abyssi	1917 to 2221
3.	Nematocarcinus ensiferus	588 to 2030
4.	Acanthephyra Agassizii	105 to 2949
5.	Acanthephyra, sp.	2929
6.	Gen. allied to Acanthephyra	1395 to 2929
7.	Hymenodora glacialis	888 to 2030
8.	Parapasiphaë sulcatifrons	516 to 2929
9.	Parapasiphaë compta	2369
10.	Amalopenæus elegans	640 to 2369
11.	Aristeus? tridens	843 to 2221
12.	Hepomadus tener	2949
13.	Sergestes mollis	373 to 2949
14.	Gnathophausa, sp.	858 to 2033
15.	Gnathophausa, sp.	959 to 2949
16.	Lophogaster, sp.	1022 to 2949

In every one of these sixteen species the eyes are present, in the normal position, and distinctly faceted. In Nos. 3, 4, 5, 6, 11 and 12 the eyes are well developed, black, and while somewhat smaller than in the average Palæmonidæ and Penæidæ,

are not conspicuously smaller than in many allied shallow-water forms. In 1 the eyes are black but conspicuously smaller than in the allied shallow-water species. In 13 the eyes are black and of moderate size. In 9 they are apparently black or nearly black and small. In 2 they are nearly colorless in alcoholic specimens and rather larger than usual in the genus, but considerably smaller than in *Pontophilus gracilis*, a very closely allied species found in 200 to 500 fathoms. In 7 and 8 they are small and light colored. In 10 they are rather small and dark brown. In 14, 15 and 16 they are not conspicuously different in size from those of allied shallow-water species and are dark brown.

However strong may be the arguments of the physicists against the possibility of light penetrating the depths from which these animals come, the color and the structure of their eyes, as compared with blind cave-dwelling species, show conclusively that the darkness beneath two-thousand fathoms of sea-water is very different from that of ordinary caverns. While it may be possible that this modification of the darkness of the ocean abysses is due to phosphorescence of the animals themselves, it does not seem probable that it is wholly due to this cause.

The large size of the eggs is a marked feature in many of the deep-water Decapoda. The eggs of *Eupagurus politus* from 50 to 500 fathoms, are more than eight times the volume of those of the closely allied and larger *E. bernhardus* from shallow water, and in *Sabinea princeps*, from 400 to 900 fathoms, they are more than fifteen times as large as in *S. septemcarinata* from 25 to 150 fathoms. The most remarkable cases are among the deep-water genera. *Galacantha rostrata* and *G. Bairdii*, from between 1000 and 1500 fathoms, have eggs 3^{mm} in diameter in alcoholic specimens, while in the vastly larger lobster they are less than 2^{mm}. The largest crustacean eggs known to me are those of *Parapasiphaë sulcatifrons*, a slender shrimp less than three inches long, taken between 1000 and 3000 fathoms. Alcoholic specimens of these eggs are fully 4 by 5^{mm} in shorter and longer diameter, fully ten times the volume of the eggs of *Pasiphaë tarda* from 100 to 200 fathoms, more than three hundred and fifty times the volume of those of a much larger shallow-water *Palæmon*, and each one more than a hundredth of the volume of the largest individual of the species. From the peculiar environment of deep-water species it seems probable that many of them pass through an abbreviated metamorphosis within the egg, like many fresh-water and terrestrial species, and these large eggs are apparently adapted to producing young of large size, in an advanced stage of development, and specially fitted to live under conditions similar to those environing the adults.

Art. X.—*Crystallized Gold in prismatic forms;* by Wm. P. Blake.

Near Clancey, on Clancey Creek, Jefferson County, Montana, minute crystals of gold occur which present the novelty of a solid octahedral nucleus, or head, with a long divergent brush-like or prismatic development of the gold on one side, or angle, giving the whole the appearance of the drawings usually made to represent comets, and as represented in the accompanying figure. The total length of these crystals does not exceed from two to three millimeters (about one eighth of an inch), and the minuteness of the cross-section of the delicate divergent prisms makes it extremely difficult to determine their form. They are, also, very brittle, and they appear to cleave or break asunder in planes at right angles to their length. Under the microscope these prisms are seen to have three or more planes and they appear to be hexagonal. They taper gradually and uniformly to a sharp point, and are sometimes composite, being for part of their length formed of two or more prisms joined side to side.

Among the fragments, one larger and broader than the others exhibits a solid octahedral nucleus with a flat or plate-like projection on opposite sides. This projection shows distinctly on one side a line of composition through the center, with divergent lines or markings at an angle of 45° with the medial line, corresponding in angle and in direction with small planes on the edges. The same side of this plate which shows the medial line of composition is slightly trough-shaped, being formed of two plane surfaces inclined towards the medial line. The opposite side is rough, with angular projections.

These plate-like projections from the octahedron are much larger than the prisms, but it is probable that the origin and crystallization of both are similar. The plates have the appearance of being formed by the combination or twinning of octahedrons parallel with their faces with their main axes inclined towards each other at an angle of 60°.

Hexagonal Prisms of Gold.

At Sonora in Tuolumne County, California, I obtained some years ago from the late Dr. Snell a sample of very small but brilliant prisms of gold. Under the microscope these are seen to be hexagonal prisms with smooth and brilliant planes and terminated at one or both ends with a pyramid. They appear

to be well formed crystals without marks of composition or twinning. The basal plane is also visible. The angle between the prism (*I*) and the pyramid (1) is approximately 130°, by measurement kindly made for me by Prof. E. S. Dana. They resemble the prismatic gold crystals figured by Prof. A. H. Chester,* and obtained artificially by digesting gold amalgam in nitric acid. He obtained 136° for the angle $O \wedge 1$, which would give 134° for $I \wedge 1$. It is possible that the Sonora crystals are also artificial, but there is no means of verifying their origin. Similar crystals obtained at Angels Camp in the same region were said to have been taken from a cavity in quartz.

The crystals described by Prof. Chester contained 6 per cent of mercury. Le Sage, a writer of the last century, 1777, also mentions prismatic crystals of gold obtained by heating the amalgam. He describes them as square prisms with terminal pyramids of four planes, and considered them to be lengthened octahedrons.

Mill Rock, New Haven, June, 1884.

ART. XI.—*Mode of action of Shell- and Rock-boring Mollusks;* by Professor F. H. STORER. (Letter addressed to J. D. Dana.)

As a teacher of Agricultural Chemistry, I have frequent occasion to insist upon the readiness with which saline compounds are decomposed by way of osmose, when put in contact with moistened membranes, and particularly when in contact with living membranes, such as cover the rootlets of plants. It has often occurred to me that a similar power of osmotic dissociation, inherent in certain animal tissues, affords the true explanation of the mode of action of many rock- and shell-boring mollusks. The power of plant-roots to decompose chemical compounds, such as common salt, for example, is only too well known to investigators. It has been in fact a serious practical hindrance to the use of the method of research known as water-culture, which has played a highly important part in the study of the question what chemical substances are necessary for feeding plants. Knop† found, for example, on growing maize plants in solutions containing the nitrates of lime and potash that the nitrogen of these compounds was taken in more rapidly by the plant than were their basic constituents, so that the solution outside the roots became alkaline through accumulation of the bicarbonates of potash and of lime. So, too, when Rautenberg and Kühn tried to sup-

* This Journal, July, 1878, III, vol. xvi, 32.

† See his "Lehrbuch der Agricultur-Chemie," i, 603.

ply maize plants with nitrogen by feeding them with ammonium chloride, they found that this salt was decomposed and that chlorhydric acid, for which the plant had no need, accumulated to such an extent outside the roots that it proved fatal to the life of the plants.* The well-known power of rootlets to leave their imprint on bones and bits of marble, with which they happen to come in contact in the earth, may perhaps be due to the corrosive action of acids set free in this way by osmotic action of the roots on matters in the soil-water; though it is perhaps equally probable that the lines are etched by carbonic acid which is known to be given off by plant roots.

In view of these familiar facts, there seems to be good reason for believing that the boring of calcareous shells and rocks by various mollusks depends on the formation of chlorhydric acid through decomposition of sea salt by certain tissues of the boring animals; these tissues being kept meanwhile in direct contact with the shell or the rock to be bored. It is to be supposed, of course, as is the case indeed with plants, that the decomposition of the sea salt, or, in other words, the secretion of the chlorhydric acid, occurs in particular organs specially suited to the purpose; but it is to be noted that in sea water these organs find an unlimited supply of the acid-yielding material. In so far as I can gather from a cursory view of an unfamiliar literature, it appears to be a fact that the boring creatures are found chiefly if not always in salt or brackish water.

Thanks to an occasional moment of attention to the ichthyological and conchological studies of my father, I have been familiar from childhood with the curiously corroded bivalves which are occasionally found in the stomachs of certain fishes taken on our New England coast, notably, unless my memory deceives me grossly, in the stomach of the so-called ling or eel-shaped blenny (*Zoarces anguillaris*) some of which specimens it should be said are extremely well-fitted to give a student just conceptions as to the great chemical activity of gastric juice. Some twenty-five years ago, in a discussion at a meeting of the Boston Society of Natural History relating to the boring of limestones by echinoderms, I cited this evidence of chemical action in the stomach of a cold-blooded fish as militating against the opinion that the echinoderm excavations "might be effected by their vibratory ciliæ"; and, in opposition to assertions that the hypothesis of chemical action was inadmissible, since a chemical agent powerful enough to soften rocks could hardly fail to destroy the tissues of the animal that produced it, I maintained that much of what we know as to the diges-

* See Johnson's "How Crops Grow," New York, 1868, pp. 170, 171.

tion of food by animals should count in favor of the chemical view of rock boring. I remember to have said, on that occasion, that it might as well be argued that tripe could not be digested in the stomach of a dog without corroding the walls of his stomach as to say that a marine animal could not bore rocks by chemical means without destroying himself.

During the last six or eight years I have had frequent opportunity to observe the common whelk (*Buccinum*) in the act of boring through the shells of mussels and barnacles, and I have interrupted his operations, scores of times, at all conceivable stages of progress. As is well known, the whelk, having seated himself upon a mussel, or other shell, thrusts out a proboscis whose end is kept continually in contact with one particular point on the mussel shell, in such wise that a small round hole is there speedily perforated through the calcareous matter. The moment the hole is completed the whelk protrudes his proboscis still farther, thrusting it into the actual flesh of the mussel, and gradually sucks out and consumes the whole of this flesh; he then passes to another mussel, drills another hole in its shell and eats the fleshy contents of the shell, as before. It has been not a little debated whether the process of perforation in this case is an act of corrosion by acid or of chipping or filing by teeth. Osler (Phil. Mag., 1832, p. 507) maintained long ago that "the perforation is effected by a succession of strokes, following each other at intervals shorter than a second." He says, indeed, that he has distinctly heard these strokes by applying to his ear a patella that had a buccinum attached to it. He gives elaborate figures of the tooth-like, horney points on the tongue of buccinum, which he compares with a "center-bit;" and, in like manner, Agassiz and Gould* have figured the teeth of natica to show the analogy of the boring apparatus to a "file" or a "rasp." The powerful muscular development of the proboscis of buccinum would of itself lend some countenance to the idea that it drives a drill. But I must say that to myself the boring act, like the subsequent digestion of the invaded mussel, has always seemed to be a distinctly chemical process. That the denticles may aid somewhat in the boring, to remove mechanically bits of loosened or softened shell, and that they may afterwards serve to tear off or hook up meat from within the mussel seems probable enough, but I am strongly of opinion that an acid solvent is made to act upon the shell during the process of boring. It seems not improbable that the presence of free muriatic acid might be detected by appropriate chemical experiments made upon large tropical gasteropods. It might even be practicable, perhaps, to learn something in this sense, by studying some one of our own species,

* Principles of Zoology, p. 78.

confined in a sufficiently small aquarium. Possibly the oyster drill (*Buccinum plicosum*) might serve the purpose? or, better, the large winkle (*Pyrula*)? or possibly even our common clam-devouring *Natica*?

Art. XII.—*Memorials of* George Engelmann *and of* Oswald Heer; by Asa Gray.

[From the Report of the Council of the American Academy of Arts and Sciences, May, 1884.]

I. George Engelmann.

In the death of Dr. Engelmann, which took place on the 4th of February last, the American Academy has lost one of its very few Associate Fellows in the Botanical Section, and science one of its most eminent and venerable cultivators.

He was born at Frankfort-on-the-Main, February 2, 1809, and had therefore just completed his seventy-fifth year. His father, a younger member of the family of Engelmanns who for several generations served as clergymen at Bacharach on the Rhine, was also educated for the ministry, and was a graduate of the University of Halle, but he devoted his life to education. Marrying the daughter of George Oswald May, a somewhat distinguished portrait-painter, they established at Frankfort, and carried on for a time with much success, a school for young ladies, such as are common in the United States, but were then a novelty in Germany.

George Engelmann was the eldest of thirteen children born of this marriage, nine of whom survived to manhood. Assisted by a scholarship founded by "the Reformed Congregation of Frankfort," he went to the University of Heidelberg in the year 1827, where he had as fellow students and companions Karl Schimper and Alexander Braun. With the latter he maintained an intimate friendship and correspondence, interrupted only by the death of Braun in 1877. The former, who manifested unusual genius as a philosophical naturalist, after laying the foundations of phyllotaxy, to be built upon by Braun and others, abandoned, through some singular infirmity of temper, an opening scientific career of the highest promise, upon which the three young friends, Agassiz, Braun and Schimper, and in his turn Engelmann, had zealously entered.

Embarrassed by some troubles growing out of a political demonstration by the students at Heidelberg, Engelmann in the autumn of 1828 went to Berlin University for two years; and thence to Würzburg, where he took his degree of Doctor

in Medicine in the summer of 1831. His inaugural dissertation, *De Antholysi Prodromus*, which he published at Frankfort in 1832, testifies to his early predilection for botany, and to his truly scientific turn of mind. It is a morphological dissertation, founded chiefly on the study of monstrosities, illustrated by five plates filled with his own drawings. It was therefore quite in the line with the little treatise on the Metamorphosis of Plants, published forty years before by another and the most distinguished native of Frankfort, and it appeared so opportunely that it had the honor of Goethe's notice and approval. Goethe's correspondent, Madame von Willema, sent a copy to him only four weeks before his death. Goethe responded, making kind inquiries after young Engelmann, who, he said, had completely apprehended his ideas of vegetable morphology, and had shown such genius in their development that he offered to place in this young botanist's hands the store of unpublished notes and sketches which he had accumulated.*

The spring and summer of 1832 were passed at Paris in medical and scientific studies, with Braun and Agassiz as companions, leading, as he records "a glorious life in scientific union, in spite of the cholera." Meanwhile, Dr. Engelmann's uncles had resolved to make some land investments in the valley of the Mississippi, and he willingly became their agent. At least one of the family was already settled in Illinois, not far from St. Louis. Dr. Engelmann, sailing from Bremen for Baltimore in September, joined his relatives in the course of the winter, made many lonely and somewhat adventurous journeys on horseback in Southern Illinois, Missouri, and Arkansas, which yielded no other fruits than those of botanical exploration; and finally he established himself in the practice of medicine at St. Louis, late in the autumn of 1835. St. Louis was then rather a frontier trading post than a town, of barely eight or ten thousand inhabitants. He lived to see it become a metropolis of over four hundred thousand. He began in absolute poverty, the small means he had brought from Europe completely exhausted. In four years he had laid the foundations of success in his profession, and had earned the means for making a voyage to Germany, and, fulfilling a long-standing engagement, for bringing to a frugal home the chosen companion of his life, Dora Hartsmann, his cousin, whom he married at Kreuznach, on the 11th of June, 1840. On his way homeward, at New York, the writer of this memorial formed the personal acquaintance of Dr. Engelmann; and thus began the friendship and the scientific association which has continued unbroken for almost half a century.

* The manuscript original of the *Antholysis*, in German, with the neat original drawings (the gift of the son), is now preserved in the Library of the Herbarium of Harvard University.

Dr. Engelmann's position as a leading physician in St. Louis, as well among the American as the German and French population, was now soon established. He was even able in 1856, without risk, to leave his practice for two years, to devote most of the first summer to botanical investigation in Cambridge, and then, with his wife and young son, to revisit their native land, and to fill up a prolonged vacation in interesting travel and study. In the year 1868 the family visited Europe for a year, the son remaining to pursue his medical studies in Berlin. And lastly, his companion of nearly forty years having been removed by death in January, 1879, and his own robust health having suffered serious and indeed alarming deterioration, he sailed again for Germany in the summer of 1883. The voyage was so beneficial that he was able to take up some botanical investigations, which, however, were soon interrupted by serious symptoms. But the return voyage proved wonderfully restorative; and when, in early autumn, he rejoined his friends here, they could hope that the unfinished scientific labors, which he at once resumed with alacrity of spirit, might still for a time be carried on with comfort. So indeed they were, in some measure, after his return to his home, yet with increasing infirmity and no little suffering, until the sudden illness supervened which, in a few days, brought his honorable and well-filled life to a close.

In the latter part of his life Dr. Engelmann was able to explore considerable portions of his adopted country, the mountains of North Carolina and Tennessee, the Lake Superior region, and the Rocky Mountains and contiguous plains in Colorado and adjacent territories, and so to study in place, and with the particularity which characterized his work, the *Cacti*, the *Coniferæ*, and other groups of plants which he had for many years been specially investigating. "In 1880 he made a long journey through the forests of the Pacific States, where he saw for the first time in the state of nature plants which he had studied and described more than thirty years before. Dr. Engelmann's associates [so one of them declares] will never forget his courage and industry, his enthusiasm and zeal, his abounding good nature, and his kindness and consideration of every one with whom he came in contact." His associates, and also all his published writings, may testify to his acuteness in observation, his indomitable perseverance in investigation, his critical judgment, and a rare openness of mind which prompted him continually to revise old conclusions in the light of new facts or ideas.

In the consideration of Dr. Engelmann's botanical work,—to which these lines will naturally be devoted,—it should be remembered that his life was that of an eminent and trusted

physician, in large and general practice, who even in age and failing health was unable—however he would have chosen—to refuse professional services to those who claimed them; that he devoted only the residual hours, which most men use for rest or recreation, to scientific pursuits, mainly to botany, yet not exclusively. He was much occupied with meteorology. On establishing his home at St. Louis, he began a series of thermometrical and barometrical observations, which he continued regularly and systematically to the last, when at home always taking the observations himself,—the indoor ones even up to the last day but one of his life. Even in the last week he was seen sweeping a path through the snow in his garden to reach his maximum and minimum thermometers. His latest publication (issued since his death by the St. Louis Academy of Sciences) is a digest and full representation of the thermometrical part of these observations for forty-seven years. He apologizes for not waiting the completion of the half-century before summing up the results, and shows that these could not after three more years be appreciably different.

A list of Dr. Engelmann's botanical papers and notes, collected by his friend and associate, Professor Sargent, and published in Coulter's Botanical Gazette for May, 1884, contains about one hundred entries, and is certainly not quite complete. His earliest publication, his inaugural thesis already mentioned (*De Antholysi Prodromus*), is a treatise upon teratology in its relations to morphology. It is a remarkable production for the time and for a mere medical student with botanical predilections. There is an interesting recent analysis of it in "Nature," for April 24, by Dr. Masters, the leading teratologist of our day, who compares it with Moquin-Tandon's more elaborate *Tératologie Végétale*, published ten years afterwards, and who declares that, "when we compare the two works from a philosophical point of view, and consider that the one was a mere college essay, while the other was the work of a professed botanist, we must admit that Engelmann's treatise, so far as it goes, affords evidence of deeper insight into the nature and causes of the deviations from the ordinary conformation of plants than does that of Moquin."

Transferred to the valley of the Mississippi and surrounded by plants most of which still needed critical examination, Dr. Engelmann's avocation in botany and his mode of work were marked out for him. Nothing escaped his attention; he drew with facility; and he methodically secured his observations by notes and sketches, available for his own after use and for that of his correspondents. But the lasting impression which he has made upon North American botany is due to his wise habit of studying his subjects in their systematic relations, and of

devoting himself to a particular genus or group of plants (generally the more difficult) until he had elucidated it as completely as lay within his power. In this way all his work was made to tell effectively.

Thus his first monograph of the genus *Cuscuta* (published in this Journal in 1842), of which when Engelmann took it up we were supposed to have only one indigenous species, and that not peculiar to the United States, he immediately brought up to fourteen species without going west of the Mississippi valley. In the year 1859, after an investigation of the whole genus in the materials scattered through the principal herbaria of Europe and this country, he published in the first volume of the St. Louis Academy of Sciences, a systematic arrangement of all the *Cuscutæ*, characterizing seventy-seven species, besides others classed as perhaps varieties.

Mentioning here only monographical subjects, we should next refer to his investigations of the Cactus family, upon which his work was most extensive and important, as well as particularly difficult, and upon which Dr. Engelmann's authority is of the very highest. He essentially for the first time established the arrangement of these plants upon floral and carpological characters. This formidable work was begun in his sketch of the botany of Dr. A. Wislizenus's Expedition from Missouri to North Mexico, in the latter's memoir of this tour, published by the United States Senate. It was followed up by his account (in this Journal, 1852), of the Giant Cactus on the Gila (*Cereus giganteus*) and an allied species; by his synopsis of the Cactaceæ of the United States, published in the Proceedings of the American Academy of Arts and Sciences, 1856; and by his two illustrated memoirs upon the Southern and Western species, one contributed to the fourth volume of the series of Pacific Railroad Expedition Reports, the other to Emory's Report on the Mexican Boundary Survey. He had made large preparations for a greatly needed revision of at least the North American *Cactaceæ*. But although his collections and sketches will be indispensable to the future monographer, very much knowledge of this difficult group of plants is lost by his death.

Upon two other peculiarly American groups of plants, very difficult of elucidation in herbarium specimens, *Yucca* and *Agave*, Dr. Engelmann may be said to have brought his work up to the time. Nothing of importance is yet to be added to what he modestly styles "Notes on the Genus *Yucca*," published in the third volume of the Transactions of the St. Louis Academy, 1873, and not much to the "Notes on *Agave*," illustrated by photographs, included in the same volume and published in 1875.

Less difficult as respects the material to work upon, but well adapted for his painstaking, precise, and thorough handling, were such genera as *Juncus* (elaborately monographed in the second volume of the Transactions of the St. Louis Academy, and also exemplified in distributed sets of specimens); *Euphorbia* (in the fourth volume of the Pacific Railroad Reports, and in the Botany of the Mexican Boundary); *Sagittaria* and its allies; *Callitriche; Isoetes* (of which his final revision is probably ready for publication), and the North American *Loranthaceæ;* to which *Sparganium*, certain groups of *Gentiana*, and some other genera, would have to be added in any complete enumeration. Revisions of these genera were also kindly contributed to Dr. Gray's Manual; and he was an important collaborator in several of the memoirs of his surviving associate and friend.

Of the highest interest, and among the best specimens of Dr. Engelmann's botanical work, are his various papers upon the American Oaks and the *Coniferæ*, published in Transactions of the St. Louis Academy and elsewhere, the results of long-continued and most conscientious study. The same must be said of his persevering study of the North American Vines, of which he at length recognized and characterized a dozen species,—excellent subjects for his nice discrimination, and now becoming of no small importance to grape-growers, both in this country and in Europe. Nearly all that we know scientifically of our species and forms of *Vitis* is directly due to Dr. Engelmann's investigations. His first separate publication upon them, "The Grape Vines of Missouri," was published in 1860; his last, a reëlaboration of the American species, with figures of their seeds, is in the third edition of the Bushberg Catalogue, published only a few months ago.

Imperfect as this mere sketch of Dr. Engelmann's botanical authorship must needs be, it may show how much may be done for science in a busy physician's *horæ subsecivæ*, and in his occasional vacations. Not very many of those who could devote their whole time to botany have accomplished as much. It need not be said, and yet perhaps it should not pass unrecorded, that Dr. Engelmann was appreciated by his fellow-botanists both at home and abroad, that his name is upon the rolls of most of the societies devoted to the investigation of nature, that he was "everywhere the recognized authority in those departments of his favorite science which had most interested him," and that, personally one of the most affable and kindly of men, he was as much beloved as respected by those who knew him.

More than fifty years ago his oldest associates in this country—one of them his survivor—dedicated to him a monotypical genus of plants, a native of the plains over whose borders

the young immigrant on his arrival wandered solitary and disheartened. Since then the name of Engelmann has, by his own researches and authorship, become unalterably associated with the Buffalo-grass of the plains, the noblest Conifers of the Rocky Mountains, the most stately Cactus in the world and with most of the associated species, as well as with many other plants of which perhaps only the annals of botany may take account. It has been well said by a congenial biographer, that "the Western plains will still be bright with the yellow rays of *Engelmannia*, and that the splendid Spruce, the fairest of them all, which bears the name of Engelmann, will still, it is to be hoped, cover with noble forests the highest slopes of the Rocky Mountains, recalling to men, as long as the study of trees occupies their thoughts, the memory of a pure, upright, and laborious life."

II. Oswald Heer.

Oswald Heer, the most eminent investigator of the fossil plants and insects of the Tertiary period, died on the 27th of September last, shortly after he had entered upon the seventy-fifth year of his age.

He was born at the hamlet of Nieder-Utzwyl, in Canton St. Gallen, Switzerland, August 31, 1809, passed most of his youth at Matt, in Canton Glarus, where his father was the parish clergyman, pursued his academic and professional studies at the University of Halle, and was ordained as minister of the Gospel in the year 1831. The next year he went to Zurich, where he resided for the rest of his life. Here he studied medicine for a time, but soon devoted himself seriously to entomology and botany, of which he was fond from boyhood. In 1834 he became Privat-docent of these sciences; in 1852, when the University of Zurich was developed, he became its Professor of Botany, and in 1855 he took a similar chair in the Polytechnicum. Most of his earlier publications were entomological; and it was by the way of entomology that he entered upon his distinguished career as a paleontologist. His life-long friend, the eminent Escher von der Linth, appreciating his rare powers of observation, induced him to undertake the study of the fossil insects of the celebrated Tertiary deposits of Oeningen. The results of his labors in this virgin field were published between the years 1847 and 1853. His attention had from the first been attracted to the plants associated with the insect remains. His first paleo-botanical paper appeared in 1851; the three volumes of his *Flora Tertiaria Helvetiæ* were issued between 1855 and 1859; in 1862 his memoir on the fossil flora of Bovey-Tracey (England) was published in the Philosophical Transactions of the Royal Society, London. About the same

time also appeared a paper, in the Journal of the Geological Society, on certain fossil plants of the Isle of Wight. For the benefit of his health, always delicate and then much impaired, he passed the winter of 1854–55 in Madeira, and on his return published a paper on the fossil plants of that island, and an article on the probable origin of the actual flora and fauna of the Azores, Madeira, and the Canaries. In this and in his work, published in 1860, on Tertiary Climates in their Relation to Vegetation (which the next year appeared also in a French translation by his young friend Gaudin), Heer brought out his theory of a Miocene Atlantis. His more extensive and popular treatise upon past climates as illustrated by vegetable paleontology, his *Urwelt der Schweiz*,—a vivid portraiture of the past of his native country,—appeared in 1865, and afterwards in a revised French edition, with his friend Gaudin (who died soon after) for collaborator as well as translator. There was also an English translation by Heywood, published in 1876, and, indeed, it is said to have been translated into six languages.

In 1877 Heer completed his *Flora Fossilis Helvetiæ*, a square-folio volume with seventy plates, which extended and supplemented his Tertiary Flora of that country, being devoted to the illustration of the fossil plants of the Carboniferous, the Triassic, the Jurassic, and the Cretaceous, as well as the Eocene formations.

The life-long delicacy of Heer's health prevented his making any extensive explorations in person. But materials for his investigation came to him in even embarrassing abundance, not only from his own country,—where, even before he was widely known (as his fellow countryman and his distinguished fellow worker in paleo-botany, Lesquereux, informs us), a lady opened upon her property, near Lausanne, quarries and tunnels expressly for the discovery and collection of fossil plants, and sent them by tons to Zurich,—but from all parts of the world collections were pressed upon him, and his whole time and strength were given to their study. In this way he became interested in the Arctic fossil flora, of which he became the principal investigator and expounder. His first essay in the domain which he has made so peculiarly his own was in a paper on certain fossil plants of Vancouver Island and British Columbia, published in 1865; and in 1868 he brought out the first of that most important series of memoirs upon the ancient floras of Arctic America, Greenland, Spitzbergen, Nova Zembla, Arctic and Subarctic Asia, etc.; which, collected, make up the seven quarto volumes of the *Flora Fossilis Arctica*. The seventh volume of this monumental work was brought to a conclusion only a few months before the author's death.

Heer's researches into the fossil botany of the tertiary deposits were very important in their bearings. They made it certain that our actual temperate floras round the world had a common birth-place at the North, where the continents are in proximity; they essentially identified the direct or collateral ancestors of our existing forest trees which flourished within the Arctic zone when it enjoyed a climate resembling our own at present; and they leave the similarities and the dissimilarities of the temperate floras of the Old and the New World to be explained as simple consequences of established facts. Thus Heer himself did away with his own hypothesis of a continental Atlantis by bringing to light the facts which proved that there was no need of it. And, while thus justifying the ideas which had been brought forward in one of the Memoirs of the American Academy (in 1859) before these fossil data were known, he was not slow to adopt and to extend the tentative views which he had confirmed.*

A list of Heer's scientific publications is given in the Botanisches Centralblatt, No. 5, for 1884. They are seventy-seven in number, besides the seven quarto volumes of the *Flora Fossilis Arctica*, which comprise a considerable number of independent memoirs. These works make an era in vegetable paleontology. Their crowning general interest is, that they bring the vegetation of the past into direct connection with the present.

Although he lived to a good old age, and was never inactive, Heer was for most of his life an invalid, suffering from pulmonary disease. For the last twelve years his work was carried on at his bedside or from his bed, assisted by a devoted and accomplished daughter; he seldom left his house, except to pass the last two winters in the milder climate of Italy. Last summer, having finished his Arctic Fossil Flora, in the hope of recruiting his exhausted strength he was removed to the most sheltered spot on the shores of the lake of Geneva, but without benefit. He died at Lausanne, at his brother's house, on the 27th of September, 1883. It has been well said of him, in a tribute which a personal friend and fellow naturalist paid to his memory, that "a man more lovable, more sympathetic, and a life more laborious and pure, one could scarcely imagine."

Heer was elected into the American Academy in May, 1877. He is botanically commemorated in a genus of beautiful Melastomaceous plants, indigenous to Mexico.

* The first and second volumes of the *Flora Fossilis Arctica* appeared in 1868–71. "Sequoia and its History," in which the writer's earlier view was extended and made clearer, and Heer's results noted, was published in 1872.

SCIENTIFIC INTELLIGENCE.

I. Physics and Chemistry.

1. *The diffusion of Gases and Vapors.*—A. Winkelmann has examined the formulas of Meyer and Stefan in order to see if they agree with carefully conducted observations. His work included observations upon the diffusion of steam; the calculation of the quotients of the diffusion coefficients; the comparison of these with the values derived from O. E. Meyer's results; the calculation of the diffusion coefficients from the observations; results upon the diffusion of ether vapor and of alcohol vapor. The apparatus consisted of a tube, the lower end of which was drawn out into a uniform tube of much narrower bore than the upper portion. This lower portion was graduated. It contained the liquid which was to be vaporized in the gas which was passed over it by an entrance and exit tube led into the wider and upper part of the tube.

For the diffusion of steam in hydrogen, in carbonic acid and in air, Winkelman finds discrepancies between the results given by Meyer's formula and those given by observation. For alcohol vapor in hydrogen, in carbonic acid and in air, and also for ether vapor in hydrogen, carbonic acid and air, a fair agreement is found with results given by Stefan's formula. It also appears that the length of the path of the molecule of the vapor can be at least approximately obtained from Stefan's formula.—*Annalen der Physik und Chemie*, No. 5, 1884, pp. 1–31. J. T.

2. *Atmospheric Electricity.*—The conference of electricians held last April at Paris has called forth various treatises on atmospheric electricity. Among these is a pamphlet entitled Continuous Observations on Atmospheric Electricity made at Florence by Professor Antonio Ròiti. The author discovered that the zero of Mascart's electrometer changed from time to time and believes that this change was due to the use of sulphuric acid as the inner coating of the charging Leyden jar. He accordingly substituted for the bifilar cocoon suspension of Mascart's electrometer a very fine silver wire which served to suspend and also to charge the electrometer needle. In this way he dispensed with the Leyden jar, and found the modified apparatus sufficiently stable. The pamphlet of Professor Ròiti contains a diagram of the electrical observatory planned and occupied by him. He also appends specimens of the curves which represent the changing electrical potential of the air. He is doubtful of the value of simultaneous observations of atmospheric electricity unless great care is taken to eliminate local disturbances.—*Pubblicazioni del R. Istituto di Superiori Pratici e di Perfezionamento di Firenze.* 1884.

Another brochure on the subject of Atmospheric Electricity by

Luigi Palmieri has been translated into German by Heinrich Discher. Professor Palmieri has conducted electrical observations on Mt. Vesuvius for many years, and entertains views on the subject of atmospheric electricity which differ from those generally entertained by other physicists. He believes that the electricity of the air is not conducted to water droppers and to metal conductors in the air but affects these conductors by induction. He does not believe that the Thomson water dropper in connection with a Mascart electrometer affords a true indication of the state of the atmosphere. An observation on the electrical state of the atmosphere should always be accompanied by observations on the state of the sky with respect to clouds and with respect to humidity. The loss from poor insulation in connection with apparatus for continuous registration of atmospheric electricity is also insisted upon as an argument against the employment of present methods. Professor Palmieri therefore urges the employment of a simple electrometer strongly resembling that of Peltier and the sudden elevation of a metal conductor in the air through a definite distance of a few feet. The pamphlet of Heinrich Discher contains diagrams of Professor Palmieri's apparatus, and is published by A. Hartleben, Vienna, Pest, Leipzig, 1884. J. T.

3. *Earth Currents.*—A number of telegraph lines, above ground and also subterranean, have lately been put at the disposal of M. E. E. Blavier, Inspector-General to the Minister of Posts and Telegraphs of France, in order to study earth currents. Some of the results of this study were submitted to the conference of Electricians held in Paris in April last. The method of photographic registration was adopted. A clock lowered a piece of gelatino-bromide paper upon which was received the image of a slit of a lamp reflected from the mirrors of three galvanometers. The latter were connected with three different telegraphic lines running in different directions. The aperiodic galvanometer of M.M. Marcel Deprez and D'Arsonval was employed: and large resistances were intercalated between the earth electrodes. These resistances were as high as 10,000 ohms. The observations were begun last September and have been continued with few interruptions to the present time. Curves for a complete lunar month, from February 28th to March 28th, 1883, are also given. No complete discussion of the curves is made; but the study of M. Blavier is evidently the most complete and systematic that has been undertaken of earth currents. If similar observations could be undertaken over extended areas in different countries our knowledge of the change of electrical potential at different points of the earth's surface would be much increased.—*Etudes des Courants Telluriques*, par E. E. Blavier, Paris, 1884. J. T.

4. *Results of the Electrical Congress of* 1884.—At the Electrical Congress held last April in Paris the various values of the ohm in terms of a column of mercury one millimeter in section

were tabulated. The results obtained by the different methods, expressed in centimeters, were as follows:

B. A.	106·21
Weber (I)	106·14
Kirchhoff	105·93
Lorenz	106·19
Weber (II)	105·47
Joule	106·22

The mean of these determinations is 106·02. The Congress decided to recommend a column of pure mercury 106 centimeters in length and one square millimeter in section at the temperature of freezing as the ohm.

The light emitted from a square centimeter of platinum at the temperature of fusion was adopted as the standard of light; and it was requested that observations on earth currents made in different countries be sent each year to the International Bureau of Telegraph Administration at Berne. J. T.

5. *A Manual of Chemistry, Physical and Inorganic*, by HENRY WATTS, B.A., F.R.S. 595 pp. 8vo. Philadelphia, 1884: (P. Blakiston, Son & Co.)—This volume, by the author of the invaluable Dictionary of Chemistry, has many excellent features and will be found a valuable guide by students who are commencing their chemical studies. The general arrangement is in some respects unusual. The leading principles are first very briefly stated in a dozen introductory pages, and then the student is led off to Physics and introduced to the fundamental laws and facts of physical science, more especially as related to Chemistry. This portion of the work makes about one-fifth of the whole and is treated with sufficient fullness to be of substantial value. After having mastered it the student is in a much better position to go forward with the study of chemistry proper. The non-metallic chemical elements are then taken up in the usual order and their properties stated with some detail, after which a digression is made to chemical philosophy, and the subjects of chemical combination, atomicity, quantivalence, etc., hinted at in the introduction, are explained at length with considerable fullness of illustration. Finally, the chemical elements are returned to and taken up in succession from the alkali metals through to the metals of the platinum group. A vast deal of information is condensed into a comparatively small space in this discussion of the chemical elements, and, as was to be expected, the work throughout is fully up to the times. A companion volume on the Chemistry of Carbon Compounds, or Organic Chemistry has also been published by the same author.

II. GEOLOGY AND NATURAL HISTORY.

1. *The Origin of Crystalline Rocks;* by T. STERRY HUNT. (Abstract, by the Author, of a paper read before the Royal Society of Canada, at Ottawa, May 21, 1884.)—The author began by

remarking that the problem of the origin of those rocks, both stratified and unstratified, which are made up chiefly of crystalline silicates, is essentially a chemical one. He then proceeded to review the dispute between the vulcanist and the neptunist schools in geology, as to whether granite and other crystalline rocks were formed by igneous or by aqueous agencies, and showed from recent writers that the controversy is not yet settled. He noticed, of the igneous school, both the plutonic and the volcanic hypotheses of the origin of these rocks, and then considered the so-called metamorphic and metasomatic hypotheses, which would derive them by supposed chemical changes from materials either of igneous or of aqueous origin. The hypothesis of Werner was next discussed. This conceives all such rocks to have been successively deposited in a crystalline form from a chaotic watery liquid which surrounded the primitive earth, and, at an early time, held in solution the whole of the materials of these rocks. The inadequacy of all of these hypotheses was pointed out, though it would appear that Werner's was the one nearest the truth.

The author conceives that the crystalline rocks were formed by deposition from waters which successively dissolved and brought from subterranean sources the mineral elements. Their formation is illustrated by that of granitic veins, and that of zeolites,—processes regarded as survivals of that which produced the earlier rocks. The true zeolites are but hydrated feldspars, while the minerals of the pectolite group correspond to the protoxyd-silicates of the ancient rocks. The sources of the elements in these rocks, according to the new hypothesis here proposed, was in the superficial layer which was the last-congealed portion of an igneous globe, consolidating from the center. In this primitive stratum, porous from contraction, and impregnated with water, resting upon a heated anhydrous nucleus, and cooled by radiation, an aqueous circulation would be set up, giving rise to mineral springs. The waters of these dissolved and brought to the surface, there to be deposited, the quartz, the feldspars, and other mineral silicates, which through successive ages built up the great groups of crystalline stratified rocks, often so markedly concretionary in aspect. Exposed portions of the primitive silicated material would be subject to atmospheric decay and disintegration, giving rise to sediments of superficial origin, which would become intercalated with the deposits from subterranean sources. The reactions between the mineral solutions from below and the superficial materials were important in this connection, probably giving rise to certain common micaceous minerals,—while dissolved silicates allied to pectolite, by their reaction with the magnesian salts, which then passed into the ocean-waters, generated species like serpentine and pyroxene.

This process of continued upward lixiviation of the primitive chaotic stratum would result in the production of a great overlying body of stratified acidic rocks, leaving below a basic,

residual and much diminished portion, the natural contraction of which would cause corrugations of the superincumbent stratified mass, such as are everywhere seen in these ancient rocks.

The source of volcanic rocks is partly in this lower and more or less exhausted stratum of comparatively insoluble and basic ferriferous silicates, whence come melaphyres and basalts;—partly in the secondary or acidic mass, which, softened by the combined agency of water and heat, may give rise to granitic and trachytic rocks;—and partly, also, it is conceived, in later aqueous deposits of superficial origin, which, also, may be brought within the influence of the central heat.

This attempt to explain the genesis of crystalline rocks by the continued solvent action of subterranean waters on a primitive stratum of igneous origin, the author designates the *crenitic* hypothesis, from the Greek, *κρήνη*, a spring or fountain. A preliminary statement of it was made by him to the National Academy of Sciences at Washington, April 15, 1884, and appears in the American Naturalist for June.

2. *Alaska glacier phenomena.*—Mr. Thomas Meehan, after an examination of portions of Alaska glaciers, states (Proceedings Acad. Nat. Sci. Philad., 1883, 249) that beneath the Muir glacier, which had been described as 400 miles long, the subglacial stream was a large and rapid torrent, being, according to his estimate, 100 feet wide and 4 feet in average depth; and that he learned from others that the flow was the same winter and summer. The glacier at its termination hung over the sea, and gave off icebergs, because of the movement of the tides, or from the gravity of overhanging portions, or through the detachment of portions by erosion due to running surface water. He shows how the subglacial stream may have become dammed by the moraine deposits and the torrent thus diverted, so as to make large drift deposits in sections of the country far away from the glacier. He remarks that the great icebergs had their lakes, rapids, water-falls, hills and valleys; that the water-ways changed their courses at times through the melting; that melting was in free progress where the sun struck, but not on the shady side of the berg.

3. *Fauna of the St. John Group (Primordial or Cambrian), New Brunswick;* by G. J. Matthew (Trans. Roy. Soc. Canada, 1882).—Treats of the remains of Paradoxides, and especially of the successive forms dependent on age of individuals in the species, *P. eteminicus* and *P. Acadicus*, here described by the author.

4. *Calcium Phosphate, or apatite, of the Canadian rocks.*—Mr. H. G. Vennor has an article in the Canadian Mining Review of January last, in which he shows that the phosphatic material or apatite occurs in a series of irregular masses of varying size, distributed along one or two planes of bedding; they run in the direction of the bedding, and, as the beds are generally upturned at a high angle, they may descend to great depths; but nowhere do they lie in veins. The containing bed consists usually of pyroxene, hornblende, and feldspar, with calcite, the apatite, and

more or less of pyrite. This bedded condition may be observed at the mines of Ottawa County, and in the Rideau section toward Perth and Kingston in the Province of Ontario.

5. *North Carolina Phosphates;* by W. B. PHILLIPS. 20 pp. 16mo.—This pamphlet gives an account of the phosphatic deposits recently discovered in Eastern North Carolina. The situation is somewhat similar to that of the phosphatic deposits of South Carolina, but as at present explored, of much less importance. The material has been found in the counties of Duplin, Brunswick, Pender and others, but not yet directly on the sea-board, and nowhere in sufficient amount to give full assurance of economical importance. The pamphlet, which purports to be a report especially on the Duplin County beds, states that the best opened localities in this county occur 4 to 8 miles north of east of Magnolia. The phosphatic material is found in sand deposits, constituting in places a thin irregular bed 8 to 12 inches thick, along ditches, dry runs and branches, and along their sides at a depth below the surface of the ground from 3 to 5 feet.

6. *Krystallographische Untersuchungen an homologen und isomeren Reihen.* Eine von der Kais. Akademie der Wissenschaften in Wien mit dem A. Freiherrn von Baumgartner'schen Preise gekrönte, durch einen methodologischen Theil vermehrte, Schrift von Dr. ARISTIDES BREZINA. I Theil, Methoden, 359 pp. 8vo. Vienna, 1884 (Carl Gerold's Sohn).—This memoir, which has been awarded the Baumgartner prize by the Vienna Academy, is a profound work dealing with the methods of crystalline determination, including the measurement of crystals, describing the instruments employed and discussing the various kinds of errors; also the methods of projection and calculation. The whole is carried through with almost too much fullness of detail and supplemented by many pages of important formulas.

7. *Cyperus.*—The first part of the 21st volume of the Journal of the Linnean Society is an elaborate essay by CHARLES BARON CLARKE, on the *E. Indian Species of Cyperus* (of 200 pages and with four plates), in which the greater part of the North American species are also considered. It will be found worthy of particular attention. The paper was partially prepared at Kew, but was finished at Calcutta.

We received at the same time a paper in the Transactions of the Linnean Society on *The Cyperaceæ* of West Coast of Africa in the Welwitsch Herbarium, by HENRY L. RIDLEY, of the Botanical Department in the British Museum, with two plates. Of seventy-one species of *Cyperus*, a dozen are found in America, but not in Asia; and so are fifteen other *Cyperaceæ*. A. G.

8. *Alphonse Lavallée.*—In the June number of this Journal (p. 494), we briefly reviewed the new work by Lavallée on the large-flowered Species of Clematis. We had recently received a letter from him, written on the 19th of April, in which he explains that certain oversights at the close of his volume were left uncorrected because an illness had prevented his reading the last

proof sheet, but that his health was now "completely reëstablished." On the third of May this excellent man died, at the age of 49. Our former notices of the *Arboretum Segrezianum* and of the other works he was engaged in may give some faint idea of the irreparable loss which botanical science (especially in relation to the investigation of ornamental trees and shrubs) has now so unexpectedly sustained. We hope to give a proper biographical memorial in due season. A. G.

9. *Chorizanthe, R. Brown: Revision of the genus and rearrangement of the Annual Species*; by C. C. PARRY. Extr. Proceedings of Davenport Academy of Natural Sciences, vol. iv, pp. 45–62. 8vo. 1884.—As this memoir was communicated to the Davenport Academy on the 25th of January, two or three weeks after Dr. Engelmann's death, and was completed within a few days of that sad event, it is appropriately and "mournfully" dedicated to the memory of his old friend.

Dr. Parry has paid great attention to this group of plants and has enjoyed unusually full means of investigating them in their native habitats. He has given a full account of the general structure of the genus, and has added two new species, besides referring to it Remy's genus *Lastarriæa*. To do this he is obliged to take the herbaceous perianth as an involucre and to reckon either that there is no perianth or that it is adnate completely to the involucre; so that the stamens are borne on the throat of an involucre! We much prefer the ordinary and obvious interpretation and should keep up *Lastarriæa*. A. G.

10. *Siliceous spicules of Sponges.*—Mr. J. Thoulet has examined the structure and other characters of the spicules of various sponges collected during the last cruise of the Talisman. They were separated by treating the sponge with hydrochloric acid. The acicular spicules lost 13·18 per cent of weight on heating to redness for ten minutes in a platinum crucible. Before the blowpipe they were whitened, or became slightly ochreous in color, without a trace of fusion. Stellate spicules of five rays lost 12·86 per cent on calcination. The specific gravity, obtained by flotation in a solution of iodides, was 2·032. But the spicules have a delicate tube along the center generally less than ·001 millimeter in diameter; and allowing for this, the author obtained, by calculation, 2·0361 as the true specific gravity—which is that of opal.

The spicules are easily attacked by different chemical agents, so that they ought to be very readily dissolved in sea-water on the death of the animal. They were analyzed after calcination by Boricky's process, by means of pure hydrofluoric acid, after first boiling in nitric acid and calcining, and they were proved to be pure silica. When not previously calcined, but simply washed, the process yielded a residue of hydrofluosilicate of soda in hexagonal prismatic crystals, the origin of which it is hard to explain unless it be that the minute tube of the spicules contains sea-water.—*Bull. Soc. Min. de France*, April, 1884.

11. *A Course of Instruction in Zootomy* (*Vertebrata*); by

T. JEFFERY PARKER, B.Sc.Lond. 397 pp. 8vo, 74 illustrations. London: Macmillan & Co., 1884.—This work certainly succeeds in its aim to be a continuation of the zoological part of Huxley and Martin's Elementary Biology, and in many ways is an improvement upon that very useful pioneer among books of this class. It gives directions for dissecting and examining the Lamprey, Skate, Cod, Lizard, Pigeon, and Rabbit—an excellent selection of readily obtainable forms. The paragraphs giving directions for each stage of the dissection are followed by careful descriptions of the structures brought into view, and in many cases the descriptions are illustrated by good figures in the text, a prominent and excellent feature of the book, which supplies a want long felt by those giving laboratory instruction in vertebrate anatomy. S. I. S.

12. *Handbook of Vertebrate Dissection;* by H. NEWELL MARTIN, D.Sc., M.D., M.A., and WILLIAM A. MOALE, M.D. Part III, How to Dissect a Rodent. 86 pp. 8vo, 6 illustrations. New York: Macmillan & Co., 1884.—This covers essentially the same ground as the last chapter of the work just noticed, and, on superficial examination, does not compare favorably with it. The animal chosen, the rat, seems a less favorable subject for dissection than the rabbit, is not so fully described as is the latter by Prof. Parker, and the few illustrations given are all of the skull, which is less in need of illustration than the brain and some other parts; but the work will be very useful when a short time only is allowable for the dissection and a small animal desirable, or when the rabbit is not readily procurable. S. I. S.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Lawrence Smith medal of the U. S. National Academy.*—Since the death of Dr. J. Lawrence Smith, Mrs. Smith has generously given to the National Academy the sum of eight thousand dollars (being the proceeds of the sale of Dr. Smith's collection of meteorites to Harvard,) the income from which is to be used for a "Lawrence Smith Medal." The following are citations from the deed of trust, with a few verbal changes:

The medal shall be awarded from time to time by the National Academy of Sciences to any person in the United States, or elsewhere, who shall make an original investigation of meteoric bodies the results of which shall be made public, and shall be in the opinion of the Academy of sufficient importance and benefit to science to merit such recognition, provided, however, that said medal shall not be awarded more frequently than once in two years, and provided also that the investigation for which it is awarded or the completed publication thereof shall have been made since the time of the last preceding award of the said medal.

If investigations of equal importance shall be made in regard

to meteoric bodies at or about the same time in the United States of America, and also in some other part of the world, each of which might in the opinion of the Academy entitle the investigator to be considered as a competitor for the medal, preference shall be given in the awarding thereof to investigations made by a citizen of the United States.

If at any time or times the interest and income of the trust-fund of eight thousand dollars shall exceed the amount necessary for the striking of said medal, and the care of the said die and of the fund, the surplus shall be used in such manner as shall be selected by the National Academy of Sciences, in aid of investigations of meteoric bodies to be made and carried on by a citizen or citizens of the United States of America.

The deed of trust and the acceptance of the fund by the Academy bears the date of the 6th of May, 1884, and the signatures of Mrs. Smith, and the President of the Academy, Professor O. C. Marsh.

2. *American Association for the Advancement of Science.*—The meeting of the American Association at Philadelphia will open on Thursday, the 4th of September (not Wednesday, the 3d, as stated on page 479), at 10 o'clock, in the Academy of Music, on Broad street. Members who intend to be present are desired to notify early the Local Committee that arrangements may be made, as it is probable that the attendance will be very large. A map and guide-book is being prepared by this committee for the members. The offices of the Permanent Secretary and Local Committee will be at the Academy of Music after September 1, and previous to this time at the Academy of Natural Sciences. The Permanent Secretary will establish his office in Philadelphia on August 22d. Titles of papers to be presented should be early sent to the Permanent Secretary, with a statement of the time the reading will require. According to the rules of the Association, no title will be referred by the Standing Committee to a Sectional Committee until an abstract of the paper, or the paper itself, has been received; and no paper will be read until it has been placed on the programme of the day by the Sectional Committee.

3. *International Geological Congress, Third Session.*—The third session of the International Geological Congress will open at Berlin on the 25th of September next, under the presidency of Dr. H. von Dechen. The sessions will end on the 30th, and be followed by excursions from the 1st to the 5th of October. The names, place of residence, etc., of geologists intending to be present should be sent to the Secretary of the Committee of Organization at Berlin, N., 44 Invalidenstrasse (Bergakadamie). The membership fee is twelve francs, and can be remitted in advance with the request to be enrolled among the members. Professor Beyrich is president of the Committee of Organization, and Professor Hauchecorne, General Secretary.

4. *Life History Album*, by Francis Galton, F.R.S., Chair

man of the Life-History sub-Committee.—The pages of this thin volume are blank forms, with directions and lists of heads, to aid the individual owning a copy to enter all the facts relating to his own physical characteristics and conditions through successive years or periods, and those of children or others dependent on him, so that a permanent record may be made for scientific deductions. It is issued under the direction of the Collective Investigation Committee of the British Medical Association. The volume has been prepared with great skill, and the putting it into general use is greatly to be desired.

A second similar volume is arranged for especially a "*Record of family faculties.*" These volumes are published by Macmillan & Co., London.

Obituary.

Robert Angus Smith (of Manchester, Eng.).—There are certain trees, like the Rock Maple of the New Hampshire hill sides, and the "Pasture Oak" of our ship-wrights, which attain a highly useful development when left to grow by themselves. Far from craving support and shelter from their kindred, or needing to be pushed or crowded into view through conflict with their compeers, they can hold out to grow most vigorously and symmetrically in the open. Doubtless some loss as to mere height is a necessary consequence of the independent habit of growth; but for practical purposes the loss is more than made good by increase of breadth and toughness. Such trees can be clearly seen, withal, because they are not in the woods.

In like manner, there appear occasionally in the outlying fields of science solitary or, so to say, detached men, who attain to stature and proportions which claim the most respectful attention of their contemporaries. It is characteristic of such men that they command success, no matter how isolated their position may be, or how completely they are separated from the crowd of common workers. To all appearance, they stand in small need of prestige or assistance, such as public position or academic chairs may give. And it would almost seem as if the very absence of outside help and of close communion with their fellows did but work for good by heightening their own individuality and inducing peculiar lines of thought which finally take full possession and become part and parcel of them. In the history of Chemistry there are several familiar examples of men who, without ever themselves making any specially brilliant discovery, or taking conspicuous part in investigations and controversies which have determined the reception of one or another class of theoretic views and conceptions, have nevertheless become eminent by sheer force of character, sagacity, and sound common sense. In this category the name of Angus Smith may most properly be placed. He possessed in high degree the sterling qualities just enumerated, together with abundant knowledge; a capacity for long-continued, painstaking, minute research; and absolute trustworthiness; and it was by virtue of these attributes that he im-

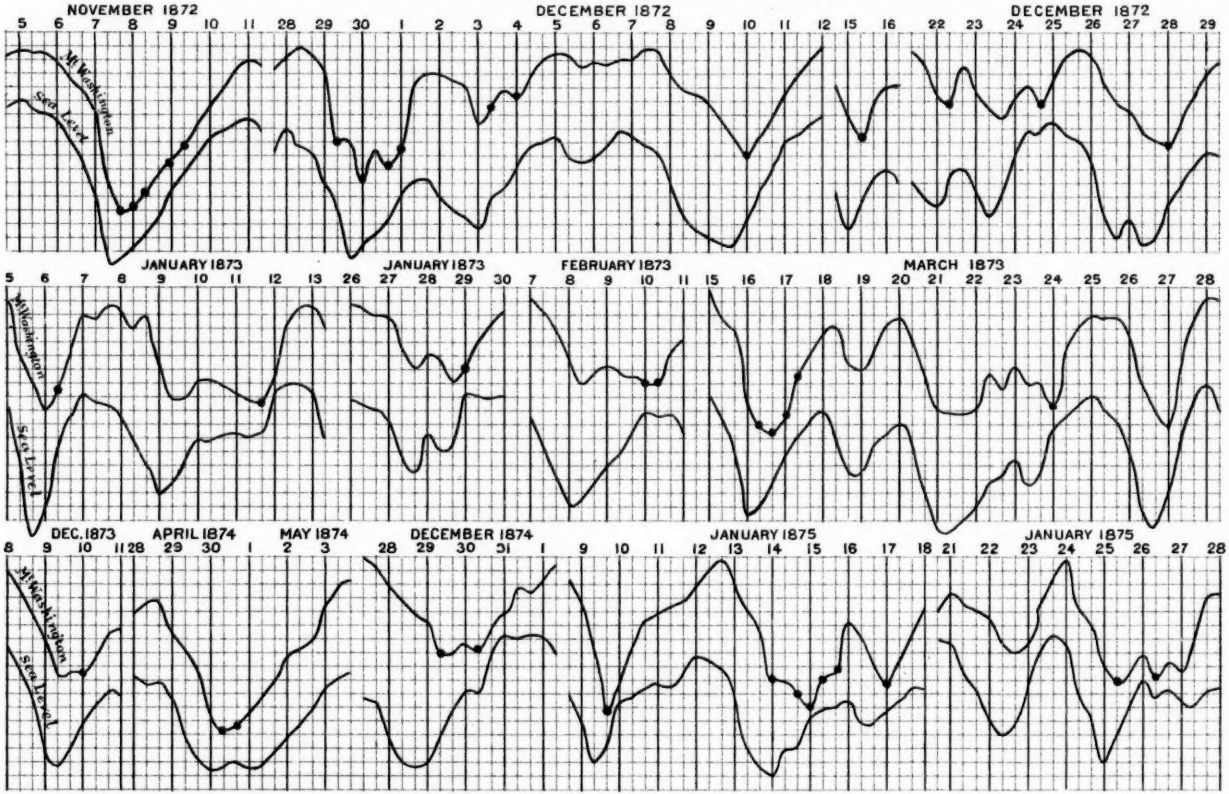
pressed himself very emphatically on the Chemistry of his day and generation. Although never, we believe, actually occupied as a teacher of chemistry, in the narrow sense of the word, he had none the less great influence as a master, here in America as well as in Europe. Indeed he long held rank as one of the most prominent chemists of Great Britain, and was acknowledged as a standard authority, the more especially in matters relating to the application of scientific knowledge to acts of legislation, particularly as regards sanitary affairs and the conduct of mines and manufacturing establishments. His researches on air, and rain, and water are well-known and widely esteemed: he himself called them at one time "the beginnings of a chemical climatology." So too are his publications on disinfectants, sewage, the air of mines, ventilation, and a variety of other subjects. Since 1863, he has done his country and humanity good service, and the cause of science as well, in his official capacity as Inspector-General of alkali works,—an office which was perhaps created for him to fill, and for the proper filling of which it may well be said that he was specially created.

Previous to the act of 1863, there had been for a generation or two a bitter feud between the soda manufacturers of Glasgow, Newcastle, and Lancashire, and those of their neighbors who, having no immediate pecuniary benefit from the works, found their fields and their families poisoned by the fumes of muriatic acid, which in those regions costs more to save than it is worth. It is safe to say that no more difficult task could be presented to a man of scientific habit of thought, accustomed to entertain conscientious scruples, than that of composing differences such as these in such manner that while the sanitary requirements of the neighborhoods should be protected or made good, no injustice should be done, in the pecuniary sense, to the owners of the gigantic manufacturing establishments or their work-people. The prudent, conciliatory, judicious, and effective—because just and wise—manner in which this most intricate problem was treated by Smith is above all praise. The conduct of the matter, as set forth in his annual "Reports under the Alkali Act," may well be studied by American statesmen as affording a most striking and instructive contrast to some of our own so-called sanitary acts of legislation and administration, notably those which have recently become notorious as disgracing all sense of justice and intelligence in one of our leading States.

Many American chemists and physicists must still remember the feeling of sympathy and good will with which they received some years since, the goodly volume entitled "Chemical and Physical Researches of Thomas Graham," which was prepared, and printed, and distributed by Angus Smith and James Young, as a tribute to the memory of their old friend and master. It was, indeed, in every sense a most worthy monument.

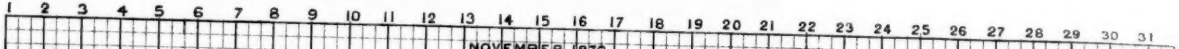
Dr. Smith was born in 1817 near Glasgow. He died May 11th, at Colwyn Bay near Llandudno, after an illness of several months' duration.

F. H. S.



BAROMETRIC FLUCTUATIONS.

PLATE 1.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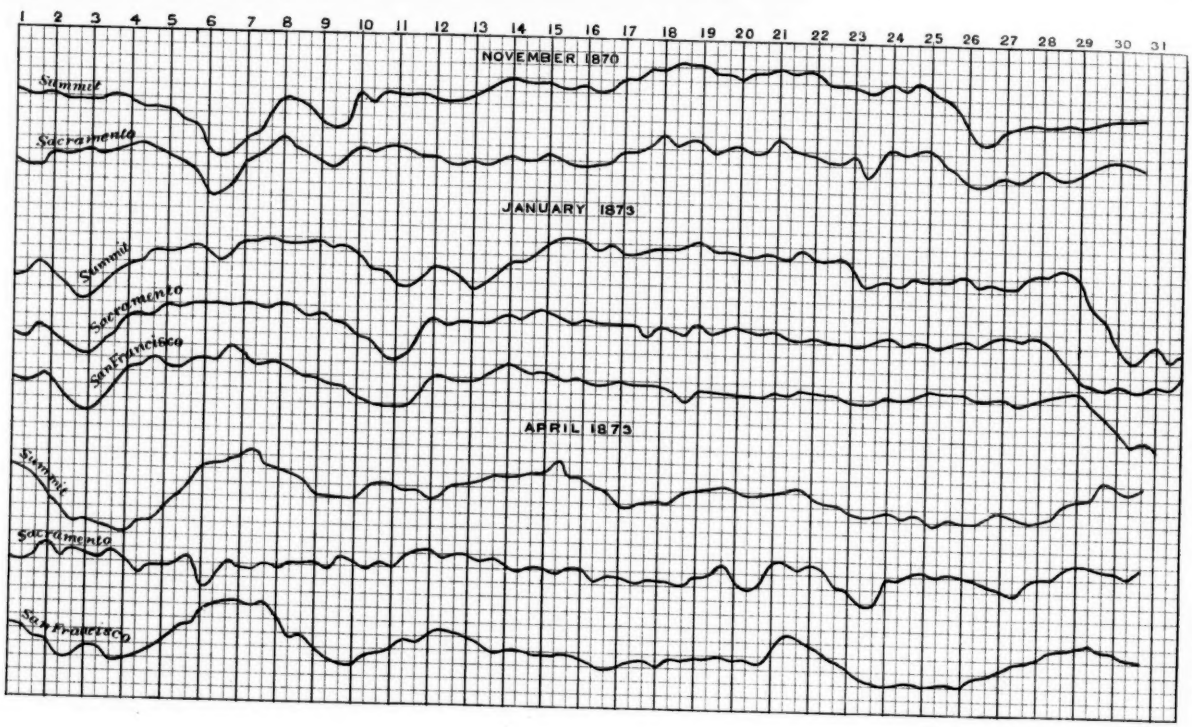

BAROMETRIC FLUCTUATIONS. PLATE 2.